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THE NEW RAILROAD STATION AT COLOGNE—(1) INTERIOR OF THE STATION. (2) TICKET OFFICE AND TRAIN ENTRANCE.

THE NEW RAILROAD STATION AT COLOGNE.

THE new railroad station at Cologne was opened informally on May 27, 1894. According to the Illustrirte Zeitung (to which we are indebted for the accompanying engravings and the following data), this is the handsomest station in the world, and there is only one, the station at Frankfort, that is larger; 103 acres of ground were required for the structure, and 140 houses had to be pulled down to make room for it. It is a masterpiece of technique, and during the whole eight years required for building it the regular work of the road, although so extensive, continued undisturbed, and there was not a single accident to travelers. That part of the road that extends from the bridge over the Rhine to the wall passes over sixteen streets, including the Hansaring, which is 131 ft. wide.

As the tracks had to be raised about 15 ft. above their former level at the main station, the entire roadbed was correspondingly elevated. For this purpose the two tracks from the middle of the bridge to the solid roadbed were raised about 3 ft. (a difficult undertaking, as it was necessary that one track should always be ready for use), and where it intersects the wall the track is more than 9 ft. above the street, then the roadbed sinks to the level of the ground.

The station proper consists of the reception building (541 ft. x 164 ft.), and behind that and 15 ft. higher, the covered space for the tracks (828 ft. x 303 ft.) with the building containing the waiting room between the tracks. The reception building was constructed from the plans of Prof. Frentzen, of Achen, and cost $297,500. In it the architecture of the present time has been given the style of the early Renaissance. At the southern end, the end toward the cathedral, the clock tower rises to a height of 144 ft., thus breaking the line of the broad, heavy mass of horizontal building and also separating it effectively from the cathedral. The tower is provided with electrical clocks. The Prince's Rooms are located in this end of the building and are connected by a staircase with the Emperor's Portal, on Frankenplatz. This portion of the building is highly and appropriately decorated.

To the north of the clock tower is the entrance hall, which is 147 ft. 7 in. wide and extends about 16 ft. beyond the front line of the building, the arch of the entrance extending about 9 ft. farther. This arch has a span of 55 ft. 9 in. The pillars at the sides of the arch are extended to form turrets 98 ft. high. North of the entrance hall is the baggage room, which is 197 ft. long and 32 ft. 9 in. high, and above which can be seen the arched roof that covers the tracks. Beyond the baggage room is the exit, which also extends beyond the line of the facade, but is smaller and more simple than the entrance.

In the entrance hall, directly opposite the door, are the ticket offices, while to the left are the offices of the sleeping car department, and to the right is an exchange office, the police room, and beyond, the bureau of information. The arrangement of this part of the building is very practical, and it is so well provided with plain signs in both the Roman and German lettering that no traveler need ask any questions, nor need he look long for anything he wants, and consequently he feels at home immediately. Everything here is so arranged as to meet the requirements perfectly, and the decorations in marble, rich wood carving, etc., are used harmoniously, but there is no overloading of artistic work.

In the baggage room there are separate places for the storage, delivery and reception of baggage, and there are eight hydraulic elevators for moving the baggage to the trains. In the exit hall, to the right, is the office for checking hand baggage, and to the left is the post office. On the ground floor of the extension are bath rooms, etc., while in the upper story there are living rooms for the station master. There are two tunnels under the roadbed leading from the entrance and exit halls, each of which is 32 ft. wide, and is lined with white tiles, and when it is dark they are made as light as day by the innumerable arc lights. In the center of each of these there is an easy staircase by which the traveler can ascend to the train, his ticket having been punched at the stairs.

The roadbed from Trankgasse to Eigelstein is 836 ft. long and 302 ft. wide, and is provided with two through tracks and two tracks for switching purposes. Between the latter is the island-like platform with the great waiting room. The entrances and exits for passengers and baggage are separate, and the mail matter is taken through tunnels directly to the yard of the post office. The entire roadbed, covering 26,551 square yards of surface, is covered by an arched roof, in the construction of which only iron and glass were used.

The building containing the waiting room is 172 ft. long, 106 ft. 7 in. wide, and about 23 ft. high. It is made of iron, covered on the outside with terra cotta and on the inside with cement. It contains a waiting room for third and fourth class passengers that covers 5,375 sq. ft., and a similar one for first and second class passengers that contains 5,160 sq. ft.; a dining room of 537 sq. ft., two bath rooms, and also rooms for the station master and his subordinates. The dining room is most elaborately decorated, the walls being covered with landscapes representing the Rhine and the panorama of Cologne, done in tiles. Some terra cotta panels on the exterior are decorated in colors with fruit and flower, and on the rear of the building are the coats of arms of Germany and Prussia, and also groups representing arrival and departure, and the coats of arms of different cities are also used in the decoration of the exterior.

An immense amount of business is done here now, ninety-three passenger trains being made up here each day, while ninety-one passenger trains come in, and the number of freight trains varies according to the requirements. Still the station is large enough to admit other lines, for the present number of travelers—3,000,000 each year—might be increased to 4,000,000 or 5,000,000 without inconvenience. The structure was a very expensive one, but certainly it was money well spent. The Chamber of Deputies appropriated $5,000,000 on April 20, 1883, and $1,800,000 more in 1892, and Cologne contributed about $120,000. It would seem that all possible needs had been foreseen and provided for, so that the structure will meet all requirements for many years to come.

GRADUATE AND POST-GRADUATE ENGINEERING DEGREES.

By ROBERT H. THURSTON, Director Sibley College, Cornell University, Ithaca, N. Y.*

THE designation of the degree to be awarded the undergraduate at the completion of his course in any engineering school has been a prolific source of discussion and even of dispute for many years. The title to be assigned the graduate student completing an advanced course in these schools has only been a less widely discussed matter because such courses have been of later origin and much less generally offered by professional schools of engineering. From the first, many schools have followed the course of the older non-professional, the purely educational, colleges, and graduated Bachelors of Science in special lines of work; others have simply labeled their graduates "civil engineer," "mechanical engineer;" still others have adopted the hybrid title "Bachelor of Engineering." The second degree is sometimes "mechanical" or "civil engineer," sometimes "Master of Science" in one or the other branch, sometimes "Master of Civil" or of "Mechanical Engineering." The doctorate, so far as the writer is aware, has never been offered in engineering except by a single institution, and as an honorary degree, and then with exceedingly great caution and very rarely. In a few instances the title conferred is entirely different from either of the old forms, as "Dynamic Engineer;" to which designation the complementary title "Static Engineer" has seldom, if ever been added. Choice has apparently been usually determined by force of example, as where the custom of the older schools is followed: by professional esprit, as where the title given is that of the profession itself; or by the spirit of innovation, as where the title is newly invented for the occasion. Occasionally, as in the case of Stanford University, the custom is established for all schools and courses alike, by the general faculty; and all graduates are dubbed A. B., whether in arts, sciences, literature, or in engineering, thus giving perfect democracy among alumni and, by the same act, taking from the degree all value for the professional, except as indicating his graduation from a reputable college. In this case, the initials of the college would perhaps constitute a still better badge.

The writer was compelled to take up this question and to promptly decide for himself as long ago as 1871, when called upon to take leading part in the establishment of a course of instruction in mechanical engineering, intended to be as distinctive in its field as was, and is, that offered at the Rensselaer Polytechnic in civil engineering. A thoughtful and careful discussion of the subject with the then best-known and most competent members of the profession confirmed his own impressions and led to the selection of the professional title rather than that of the older class of schools and colleges. The latter, having at least the merits of novelty and logical correctness, was rejected simply as not likely to find favor with either the followers of the gymnastic schools or members of the profession. The reasons for the final decision are simple and easily summarized: The school to be established was intended to be a professional school, distinctively. It was important that the degree offered should, if practicable, indicate that fact and give some presumption that the student graduating from its professional course might be expected to exhibit some special fitness and preparation for entering and advancing in that profession. It was desirable that neither the school, the course, nor the graduate should be confounded with those schools, courses, and graduates, so nearly universally recognized as below the standard set by the profession, the schools organized in connection with the older institutions of learning, controlled by non-professionals, by the clergy largely, and offering singularly inadequate courses of instruction; graduating students neither educated nor professionally trained, hybrids comparatively weak in educational branches and usually compelled to unlearn much of their "professional" instruction before they could be intrusted with any really useful office or field work.

At that time and in nearly all such schools, the attempt was being made, under the pressure of the non-professionals in control, whatever the views of the engineers nominally in charge, to give at one and the same time a college education and a professional training in four years, sometimes in three; notwithstanding the now recognized and obvious fact that either education, to be satisfactory, should occupy the full term and demand steady and earnest application throughout. The fact that the student must either get his education first and his professional training later, as in law, medicine, or any other profession, or must choose either the one or the other, was not then as generally admitted as now, and the most singular mixtures of literature, history and other non-professional studies with engineering were often prescribed; as where, in one now famous institution of learning, "biblical exegesis" constituted a portion of the regular course in engineering, or where, as in the early days of Cornell University, Roman history was similarly embedded in a course nominally that in civil engineering, "like a fly speck on a white wall," as the finally emancipated head of the department was accustomed to say. In the same institution, in the earlier days, we had a course of instruction in "English" for years; taking the place of professional work in mechanical engineering, injuring the efficiency of the course while giving practically little advantage as literary training. This subject is now obtained, with better results, in the preparatory schools, and the consequent elevation and improvement of the course, now demanding more of preparation before entering, gives an average student better literary standing at entrance than he formerly had at graduation, and at the same time permits his securing a comparatively satisfactory and truly professional training. It was recognized, finally, that a professional training is not an education, in the correct and accepted signification of the term, and that the best obtainable education should precede the work of the professional school. Each should do its work independently, if it is to be done well. Either attempting the work of the other, must prove more or less of a failure in proportion to the fraction of time given to the foreign element. A good professional school, devoting all its time to its legitimate work, still finds that it has no time to spare, and usually that more time still would be acceptable. For these hybrid courses of the older regime the older designation was recognized as appropriate enough. They were not, properly speaking, professional schools; they were, in considerable degree, schools of applied sciences. With them Bachelor of Science was as appropriate as a title as for the schools of pure science beside them.

It was thought by the strongest men in the profession that the professional title would prove more acceptable for the distinctively professional school, both as being more appropriate, in view of the more nearly professional nature of the school, its closer approximation to the standard set by the other professional schools, as of law and of medicine, and as being more likely to satisfy the demands of the student and alumnus, a matter in itself of some importance. It was also thought by many that the old Latin term bachelor was hardly consonant with modern and popular ideas; the classical and somewhat incongruous shade of tone being likely to strike unpleasantly upon the ear of any one at all inclined to be critical in matters involving literary taste and accuracy. "Bachelor of Science in Engineering" was not so bad; but "Bachelor of Engineering" seemed, to many, entirely inadmissible.* For the second degree, however, the good old English term "Master" awakened no opposition, and a "Doctorate in Engineering" was admitted on the ground that engineering was coming to be recognized as a learned profession, and was actually demanding more of its practitioners in its scientific preparatory work than the other professional schools, and its highest order of practice might well be considered to entitle the practitioner, thus standing at the head of his profession or in its front rank, to the designation of Doctor.† The popular assumption that the title is confined, properly, to the profession of medicine has no basis in derivation or practice. It was these considerations, mainly, which led the writer, personally, and he thinks the majority of the abler members of the profession and the acknowledged leaders of the time, to agree upon the use of the title of the profession for a first degree and to adopt a Master's degree for a second and the Doctorate for the highest degree proposed.

On the establishment of the course offered in 1871 at the Stevens Institute of Technology, so far as professional, by the writer, then the professor of engineering of the newly organized school, the undergraduate course led to the degree "Mechanical Engineer," while the advanced courses were left to be established later. The honorary degree of Doctor was in a few instances conferred. Post graduate courses had not been established at the time of the transfer of the writer to Sibley College, Cornell University, in 1885. When taking the directorship of this institution, the writer was authorized and directed to organize and establish its courses of instruction, to create departments of study and professional work, and to select and nominate the incumbents of the several chairs; in fact, to completely organize a school of mechanical engineering, and to set it in operation. The same considerations which had determined the partial adoption of the scheme of 1871 at Hoboken induced the recommendation of a similar scheme for the new college. The titles proposed for the first and second degrees were adopted. The doctorate has not yet been established, although large numbers of graduate students are working for the second degree, and the indications seem to be favorable to the experiment of establishing the higher course of professional work, possibly a three years' course in absentia, with commutation of one year if worked out entirely in the college under the immediate supervision of its faculty.

In 1893, ninety-three took the first and fourteen the second degree. In 1894 the number taking the second degree was seventeen, the total being a little less than in 1893. In 1893 and in 1894 over sixty candidates were on the lists for second degrees in 1893 and later. Many were instructors taking three or four years to perform the work, being seriously impeded by their daily duties. The number graduating in 1886, the year in which these courses and degrees were first put in effect, was five, taking the first degree. In 1887 sixteen took the first and three the second degree, and from that time on the growth of the institution was exceedingly rapid, and was attributed, in part, to the wisdom shown by the faculty in the adoption of the professional title for its degree. Of this, of course, there can be no really crucial proof; but it was probably one of numerous conspiring causes.

There are various objections urged against this system of nomenclature of degrees, some of which undoubtedly have weight, some of which are as unquestionably farcical. That most commonly and most seriously urged, perhaps, is the undesirability of conferring a degree which is at the same time the designation of the profession itself. This seems to the writer rather an argument for than against the title chosen. The undeniable fact that the graduate is only prepared to begin to learn the essential practical routine of his vocation, and is not and cannot be prepared to practice, has no more weight than in medicine, where every graduate is a "doctor." The fact is well understood by every one that his title, as conferred by the school, is simply an assurance that he has had a course of professional instruction, and is thus given a certain indispensable preparation for entrance into the profession which he has chosen, precisely as in any other profession. The degree "Civil" or "Mechanical Engineer" gives no more presumptive evidence that he is competent to practice than does the degree of "Doctor of Medicine" in that field. Neither ever is or ever will be misunderstood. It is just as true that a master's diploma in science, literature, arts, or

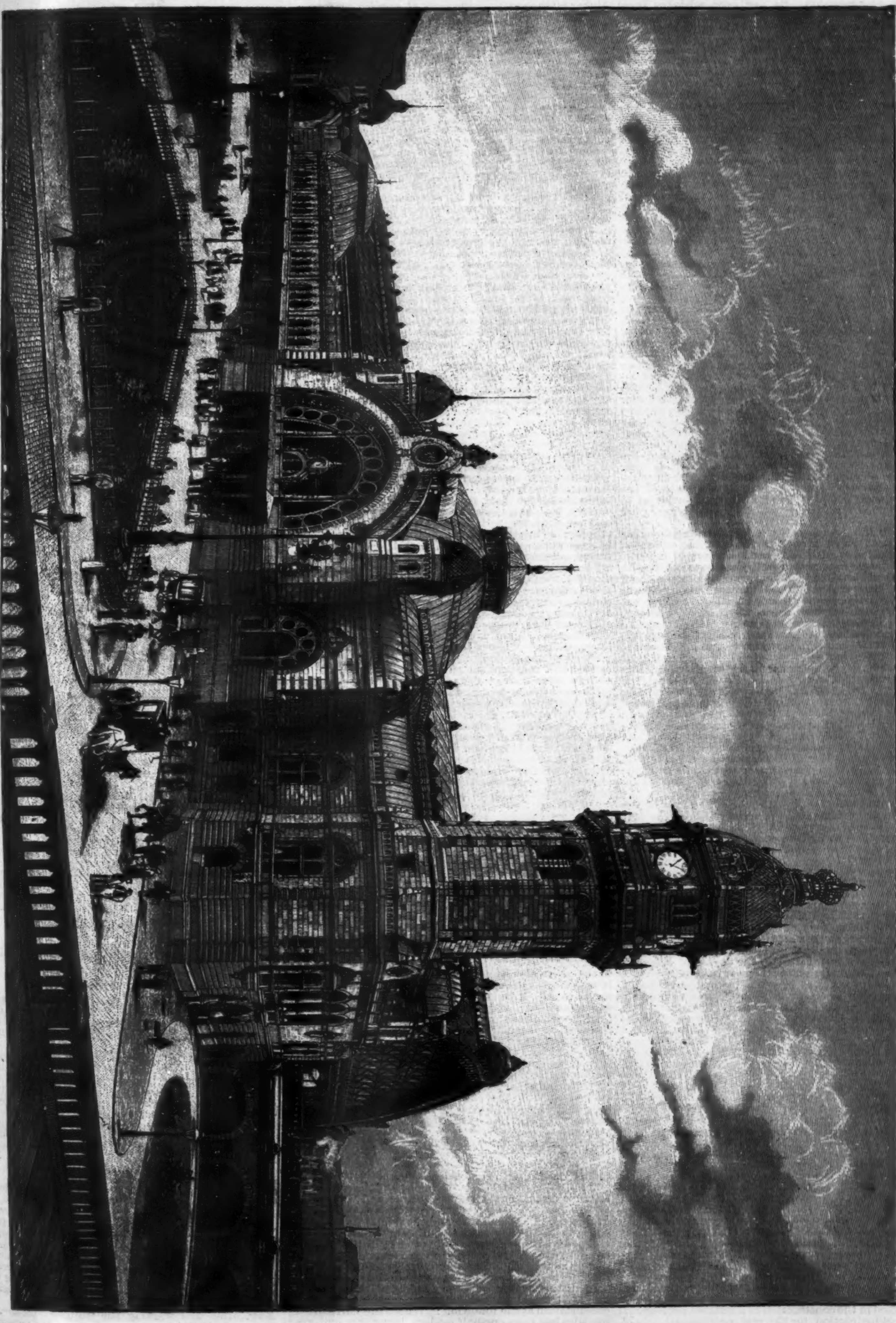
* A paper read before the Society for Engineering Education, at the Brooklyn meeting of the A. A. A. S., 1894.

* The term bachelor is from the Latin, baccalaureus, one crowned with laurel. In the French it becomes "a young squire, not made a knight." Its first English meaning was "a young, unmarried man." In old times the student undergraduate was forbidden by the law of the university to marry, on pain of expulsion. Violation of this law by William Lee resulted in his invention of the stocking loom.

Master is from the old Anglo-Saxon maester, one who has attained physical superiority over other men, later, one who is superior in any art, profession, science or department of learning. The first of these two collegiate titles is, in the opinion of many members of the profession, as incongruous for the engineering schools as the second is appropriate.

† Doctor: from the Latin doctor, doceo, doctus, to teach: designating, in English, one who has received the highest degree from an institution of learning; one who is learned, an expert and an adept; a teacher of his craft.

THE NEW RAILROAD STATION AT COLOGNE—GENERAL VIEW OF THE BUILDING FROM THE TERRACE OF THE CATHEDRAL.



THE NEW RAILROAD STATION AT COLOGNE—GENERAL VIEW OF THE BUILDING FROM THE TERRACE OF THE CATHEDRAL.

engineering gives no assurance that the holder is a master in the vocation he may have selected; it is simply the certificate of a reasonable proficiency in those branches of learning which are customarily pursued in such courses as are prescribed as leading to the stated degree. The same is as true of the doctorate in any branch or profession. No one ever mistakes these diplomas for certificates of proficiency in anything outside the courses of the schools to which they each specifically appertain.

It is the business of the schools of the professions to make certain that these diplomas, however, represent as strong, condensed, and fruitful a course each, in the sciences underlying the profession, as the state of contemporary science and professional learning and practice permits—that is to say, so much of human knowledge as bears upon that vocation in the form of the history of the development of the art and its state at the time, the applied sciences so far as they bear upon professional work, the literatures of our own and other nations so far as they have professional importance, the methods of allied arts, so far as they can properly be described and illustrated in the lecture room, class room and laboratories, and the theory and practice of scientific research, so far as bearing upon the problems arising in practice or in the development of the sciences finding application therein. In many cases, even the practice of the profession in certain important lines may be taught and illustrated, and to that extent the graduate is often better prepared for business than his older and less favored colleague, who has never had the advantages of systematic instruction and laboratory practice. It is the business of the professional school to develop methods of reducing the work of the practitioner to scientific form and method, and to that extent to teach the practice as well as the theory of the art. It is in this manner that the methods of scientific determination of the efficiency of steam engines, boilers, and other apparatus of the engineer have come to constitute a part of every course of instruction in any truly engineering school. The chemistry and physics of the development and transfer and storage and transformation of heat in the production of mechanical energy is thus supplemented by the engineer's practice, in measuring the useful effect obtained from a stated quantity of thermal energy thus derived and dealt with. In engineering, the schools are schools of applied science, and it is their purpose and duty to make the instruction in application as extensive and complete as the state of the sciences and the arts permits, quite as much as to give a good knowledge of the underlying pure sciences.

To dub the graduate of a professional engineering school Bachelor of Science, or those taking advanced courses, Masters of Science and Doctors of Science, seems as inaccurate and unsatisfying as would be the adoption of the same system in any other professional schools. Law and medicine are based upon sciences and their practice is a system of applied science; but the distinction between the student of pure science and the professional is wisely preserved by emphasizing the professional side, that of application; and the doctor in medicine or in law, just as much a scientific man as his neighbor the engineer, is designated by terms which leave no possibility of confounding him with the chemist, the physicist, the physiologist, the biologist, whose learning he must always borrow for his professional work. Similarly it would seem that the engineer should be distinctively designated as an expert in scientific professional work, not as a man of science simply. John Doe, M.E., or Richard Roe, C.E., is unmistakably marked professionally; John Doe, B.S., or Richard Roe, B.S., presumably a student of sciences, is certainly not likely to be taken by the stranger reading his card as legitimately inducted into the profession which he may claim as his.

Perhaps the most potent argument in favor of the adoption and retention of the special title is the fact that a very large proportion of the graduates of engineering schools, and an increasing proportion, are carrying that title. Another important consideration is the fact that the recipients of the degrees given prefer the professional title. When, with the advance in the requirements for entrance and the considerable accompanying improvement of the professional courses at Cornell, some years ago, the title was changed from Bachelor to Civil and Mechanical Engineer, it was provided that for the time either title might be received, at the option of the graduate, in electrical engineering courses, not one graduate, out of scores taking that course of study, ever called for the degree of Bachelor of Science; all preferred the degree giving professional distinction, precisely as in other professional schools. That provision still stands; but it has completely dropped out of sight through non-application. The young graduate aspires to be known as a member of a profession and an aspirant in engineering, not as a student in science, simply; however honorable and honored the latter vocation may be. His pride lies in professional success, and all his hopes, ambitions and labors tend that way. Even the title assigned him by his alma mater, intrinsically unessential as it in fact is, becomes to him a matter of interest and pride and assumes real importance.

This form of diploma is preferred by the greater number of the representative men in the profession. They welcome the young engineer into the profession, and adopt him into the society, not as distinguished as a student in the sciences, but as one whose ambitions lie in the same line with their own, as one who aspires to follow in their footsteps, to emulate and improve upon their work, to accomplish all that talent, genius, education, industry will permit in what their seniors regard as the noblest of the professions, the most useful and fruitful of direct good of all the vocations. They welcome him as a novice in engineering and take him into the profession as one of their own family. The school is simply the first stage of professional work, and its title should indicate that fact.

The question of designation of the degree conferred is, after all, a small matter beside the problem which is involved in the construction of a suitable professional course of instruction for the real professional school. By real professional school is here meant an engineering school, in which the work is purely that of professional preparation and instruction, precisely as in any real professional school of law or of medicine, and which no working time is sacrificed to general education, to "culture," or to purely gymnastic studies. Its requirements for admission are, properly, simply those branches of learning which necessarily preface the work of the professional, as mathematics up to the point at which, either, the schools from which the candidates for admission mainly come, cease to teach the higher mathematics, or the work of applied mathematics of the science of the profession properly begins. These requirements do not properly include any branches not finding later application either directly in professional work or as introductory to studies or laboratory work forming a part of the professional course. The course itself properly consists of just so much of the sciences, the arts, the literatures of contemporary and earlier times, finding application in the practice of the profession, as essential elements of professional work, and so much of methods of application, as can be systematically given in a course of the length assumed as practicable. In engineering schools, four years is generally thought none too long for even the purely professional course; in schools of law and medicine, two years, and often less, may be admitted. The engineer has come to be the most completely trained, the most learned, among professionals. Given, as is now not uncommon, a good preliminary course of culture, of general, of gymnastic, education, supplemented by a full course of professional training, in a real professional school and in the higher school of practice, he is necessarily the most thoroughly educated and at the same time the most learned of professional men. James Watts was perhaps the leading member of the Lunar Club, composed of the great scientific men of his time; the modern engineer, who has enjoyed all the opportunities coming to the man of moderate circumstances of our time, and who has taken full advantage of them, or who, as a "self-made" man, has acquired both an education and a professional training, may always emulate Watt in this direction. But, whatever his location, position or specialty, the ideal and representative member of the engineering profession, hereafter, will be a man of ability, strength, and supreme integrity, who has secured the best education that the best university can offer, or that can be obtained by study and travel, perhaps, followed by the best professional training that the best professional schools can give, and who has shown by his works that he is a fit disciple of Telford or of Watt. It is of comparatively little consequence what title shall be conferred by the schools upon this representative engineer.

Reviewing the field, it would seem probable that a variety, both of courses and of titles, must be accepted and endured for a time. Colleges and professional schools alike must usually be restricted and controlled in their work by the possibilities. All seek to make their requirements for admission as high as practicable; all are compelled to accept what they can, for the moment, secure from the preparatory schools. The so-called schools of engineering will, probably for years to come, in some sections of the country and under ordinary local conditions of environment, be compelled to offer semi or partial, professional courses; incorporating with the elementary work of the purely and truly professional more or less of the gymnastic and educational work of the non-professional schools. A few and perhaps usually the independent engineering colleges, will be able to offer courses demanding the higher mathematics and the modern languages, in part, for entrance, and consisting mainly of professional work and studies in applied science. Now and then one, the numbers probably increasing with the progress of time, may be able to secure full preparation for a purely professional curriculum, and may thus attain the standing of a real and unadulterated professional school. Such technical colleges, whether independent or connected with the universities, must probably long remain few in number, possibly small in magnitude.

The first of these classes of school, with its mixed course, its limited professional, largely educational, curriculum, ought not, in fairness, to receive the title of professional school; it gives simply a course of study which properly takes its place as a modification of the usual and standard higher courses in science, of the non-professional colleges and the universities, and its degree should, obviously and naturally, following convention, be that of Bachelor of Science, and the reading of its diploma may be qualified by a statement of the special branch which constitutes its characteristic feature. It would be neither logically correct nor fair to its graduates or to the profession to unqualifiedly call this a professional school, or to give its graduates what might be interpreted to be a title to entrance into the profession as from a truly professional school. It would be as wrong, and exhibit as serious incongruity, as to dub M.D. the graduate of a high school in which anatomy, physiology and hygiene had been taught with exceptional development at the expense of the usual and regular high school studies, or M.E. when manual training had been similarly added to the older courses, with an attempt at teaching applied mechanics without adequate preparation in the calculus and accessory mathematics, and without laboratory or other higher training in mechanics and the physical sciences.

The second of these classes, once it has succeeded in fully emancipating itself from the thraldom of the preparatory schools, in formulating its courses on a correct basis of applied science, and in making them completely professional, will probably prefer to give a title to indicate that fact; as have for many years already, some of the leading schools, even before reaching that higher stage. With these schools on a level in position and standing with the law schools, and having, as a rule, higher requirements for entrance and a stronger, as well as much longer, course of work in exclusively professional lines, the wise and the politic plan would seem to be to give titles denoting and defining their character with honesty and directness; distinguishing themselves from the schools of mixed curricula as completely as from those of an absolutely non-professional kind. The title should be apposite to the work.

In distinguishing between schools of these several grades it would perhaps be well to make some such classification as the following: Where the curriculum includes less than one-half modern languages and applied sciences, and, commencing in the line of mathematics with elementary algebra and geometry and terminating with elementary applied mechanics in the senior year, requires for entrance the common school branches only and contains no laboratory instruction, except in chemistry, I would consider the course as in no sense a really professional one and would give the degree of Bachelor of Science simply. Where plane geometry and elementary algebra through quadratics are required for entrance on a four years' course, in which one half or more of the work is in modern languages and the applied physical sciences and in laboratories, and where the applied mechanics—a strong course in that subject—comes in the junior year, as introductory to professional work in the senior year, I should consider that we have reached the border line and would give either the bachelor's degree in engineering or the professional title, accordingly as the character of the course in detail approximates the one or the other, pure or applied science, most closely. Where a four years' strong course of applied science and mainly professional work is offered, its applied mechanics in the junior or the sophomore year, the higher mathematics being required for entrance, all purely educational and gymnastic study being supplanted by work directly bearing upon the main purpose of the course, and with extensive lines of laboratory work, in the sciences and in engineering, in the junior and senior years, the school of engineering becomes fully the equal in rank with the schools of medicine of the highest class and superior to the average, and stands above all the law schools in length and strength of professional courses, and should unquestionably offer the professional titles.

The practice of the engineering schools seems to be approximating this classification already, and the schools giving the first and second forms of curricula are, in many cases, offering the title given by those approximating the last form, after a specified amount of graduate work has been performed, while the higher class of professional school is taking the graduates of the others for post-graduate work in professional branches and offering them the appropriate degree, often supplemented later by its own advanced degree. It is, in fact, not a bad plan for the student desiring to secure a good scientific training in engineering to take his first (B.S.) degree in the nearest and most convenient school or college, advancing, after graduation, into the semi-professional school of the second grade, and finally completing his work in the purely professional school, and perhaps even then taking an additional year for laboratory work and research in lines in which he proposes to specialize, taking a master's degree, or its equivalent, in conclusion of his final work. Such cases are not unknown in my own experience, and seem likely to become somewhat common hereafter, as the number of students seeking graduate work in engineering is rapidly increasing.*

Such a course is thought by many in the profession, as well as outside it, to constitute the ideal preparation for work in life. The young man fortunate enough to be able to give the time and to pay its cost, securing first an education and then a professional training such as will in the end permit his easy acquirement, if he have the talent—without which none should enter upon such professional work—of reputation and competence, and enable him to make profitable use of all those opportunities, professional, or, and especially, in culture, which come only to the educated, as well as professionally accomplished, man. This is coming to be a common plan of education with able and thoughtful young men, and the number adopting it is rapidly growing. Students completing the courses in arts and in letters in our universities are sometimes, and in constantly increasing numbers, doing the same thing, and thus securing, first an education, second, a professional, scientific training in engineering. Such men reach the level of experimental investigation comparatively easily and quickly, and enjoy, as does none other, that highest pleasure of combining study with original research in previously unexplored fields of science and professional work. Although so long and so powerful a diversion of the mind from practical matters is apt to give a permanent set to the mind of the student having insufficient talent for work, converting him into the impractical theorist, those who have the genius for engineering cannot be seriously affected in this manner, and the right man, in his right place, ultimately profits enormously by such a training. Opportunities come late, usually, and he has all the years from his leaving college to the age of thirty five or forty to fit himself into his place in professional practice.

INTENSIFYING NEGATIVES—IMPROVED METHOD.

By JOHN VANSANT, M.D.

THIS subject, though somewhat hackneyed, is not exhausted or unimportant; nor has a perfect method of increasing the density or improving the detail of a thin photographic negative, so far as I know, been heretofore published.

Of all the known methods, that commonly called the "mercurial method" seems to be the most used and is, doubtless, the best. It is simple, easy of execution, and will often improve the printing quality of a negative. But it is at best, as usually employed, very imperfect and unsatisfactory. From time to time I have made many experiments endeavoring to find a practical solution of the difficulties, and have recently, I believe, succeeded in this, and recommend for trial the following process to all interested. But before stating this, it may be well to glance at the present modes of procedure and their deficiencies.

The negative image, being composed of metallic silver in a minute state of division, when exposed to the action of a watery solution of mercuric chloride (say a grain to the ounce), takes one atom of chlorine from the mercurial salt and becomes white silver chloride, while the molecule of mercuric chloride is at the same time converted, by the loss of chlorine, into mercurous chloride, or calomel, also white, which is deposited along with the silver chloride, much increasing the bulk and weight of the latter and of the original metallic image.

Now, after well washing the whitened picture, to free it and the film from every trace of the mercurial solution used, the object is to convert the silver chlo-

* The numbers registered for the work of this kind in Sibley College in 1892-93 and 1893-94, respectively, out of 560 and 620 students, were 64 and 68; of these 14 and 17 took the master's degree.

ride and calomel image into a black opaque image, and to do this without diminishing its bulk.

Having this in view, four modes are followed, viz. (1) that by the use of ammonia water; (2) by sodium sulphite solution; (3) by lime water; (4) by ferrous oxalate solution.

If ammonia water be used, the calomel will be changed into a black, insoluble compound, but the silver chloride will be dissolved in whole or in part, according to the strength of the ammoniacal solution and the length of time it may be applied; the result being that the image may be little or no denser than before the attempt at intensification.

If sodium sulphite be employed, the black compound first formed by reaction with the calomel is freely soluble in excess of the sodium sulphite, and is finally reduced by a weaker solution to metallic mercury; while the chloride of silver is also soluble and the white color of any remainder of the latter salt is unchanged. The result will be a clear, dark image, but thinner than the original, and liable to change by keeping.

When lime water is used, the calomel is completely changed into a black insoluble compound, but the silver chloride is not blackened, nor is it dissolved; the surface of the gelatine is left matt.

If ferrous oxalate solution be used, both the calomel and the silver chloride will be reduced to the metallic state, and the original image will be thus increased in density by the amount of mercury deposited on it, but not at all by the silver, and this amalgam of silver and mercury is liable to change in color and density on exposure to the air.

Thus it is seen that none of the methods employed are capable of accomplishing the object desired—i. e., of changing the argentic chloride and mercurous chloride, composing the whitened image, into black, insoluble and practically unalterable compounds of silver and mercury (oxides), having much greater bulk and opacity than the original silver deposit. This can, however, be done as follows:

Immerse the thoroughly washed and soaked whitened negative in a freshly prepared solution made of

Pure water....	4 fluid ounces
Gallic acid	½ grain
Caustic potash (KOH)...... ..	2 grains

Allow the negative to remain in this solution till the picture becomes blackened through, gently rocking the containing tray. This will usually only require a few minutes. A longer immersion can do no harm other than possibly to stain the film slightly or cause it to frill. After this it is simply necessary to wash well and dry the negative.

It is important not to vary the proportions of the ingredients given above to any great extent, and also it is best to use the solution immediately after it is mixed, as it rapidly deteriorates from absorption of the oxygen of the air.

The small amount of gallic acid employed seems to be necessary only to start the decomposition of the silver chloride into oxide by the potassium hydrate, which, otherwise, will not occur; though the mercurous chloride is readily converted into black oxide of mercury by the potassium hydrate alone. Neither gallic acid alone, nor caustic potassa alone, can decompose silver chloride.

It must be remembered that it is the formation of the black oxides of the two metals that is desired, and not the reduction of the haloids to the metallic state.

Tannin can be substituted for the gallic acid in the above formula, but it is less active, does not give so black a color, and renders the film very hard; this last property being in some cases useful. Tannin is also more apt to cause a slight yellowish staining of the film. Hydroquinone and pyrogallol are too active and cause reduction of the mercury especially to a gray metallic powder. The blackening of the silver chloride can be notably hastened by exposing the whitened negative to the sun for a few minutes before immersing it in the alkaline fluid above mentioned.

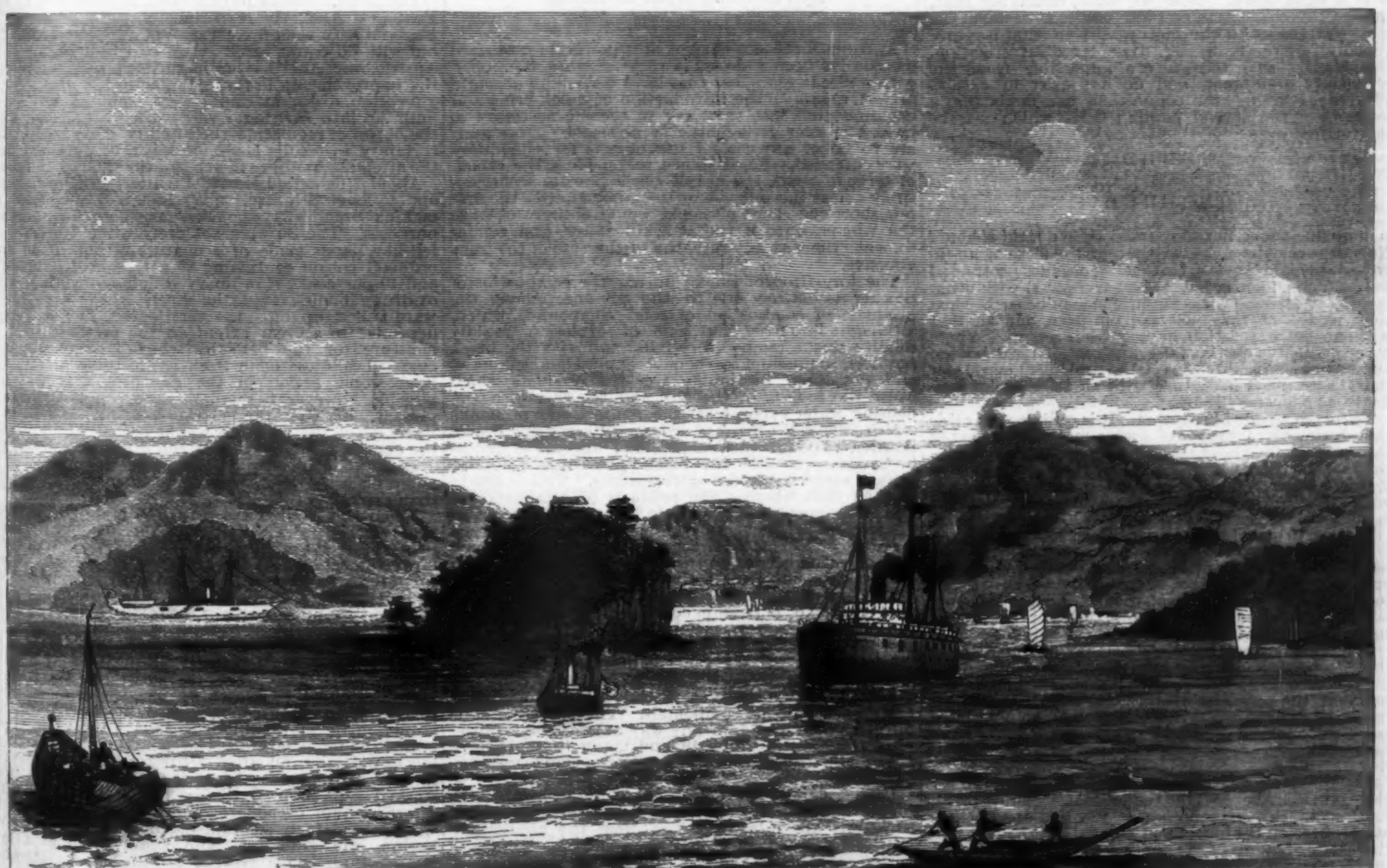
By the method above recommended all the deposit is saved and the original image is greatly increased in density, while the clear parts of the negative remain uninjured.—St. Louis and Canadian Photographer.

THE MIKADO MUTSUHITO, EMPEROR OF JAPAN, COMMANDER-IN-CHIEF OF THE ARMY.

THE WAR IN THE EAST.

NAGASAKI is the leading seaport on the western coast of Japan, on the island of Kiushiu. The harbor is formed by an inlet of the sea, stretching northward for a distance of about four miles, is about a mile wide and is inclosed on both sides by a framework of hills about one thousand five hundred feet high and is adorned with picturesque islands. The island in the center of the channel, with the observatory station, as shown in our engraving is the celebrated Pappenberg, the scene of the massacre of the Christians in 1638. The channel is commanded by earthworks on the hills. The entrance to the harbor of Nagasaki is protected by submarine mines, and all ships entering or leaving the harbor must be piloted through by government launches. Our engraving shows a government pilot-boat guiding a Peninsular and Oriental mail steamer among these submarine mines. The guard ship to the left is the Ho-sho, one of their oldest ships, having been launched in 1868. The city lies near the upper

THE EMPEROR OF CHINA, TSAI-TIEN HWANG-TI.



ENTRANCE TO NAGASAKI HARBOR, JAPAN.

end of the inlet on its eastern side and has a population of about 80,000. It has a magnificent dock, and several fine public buildings, including an excellent government school. The city is laid out with great neatness and regularity, the streets crossing each other at right angles.

The war in the far East between China and Japan has awakened widespread interest in those countries and their rulers. Mutsu Hito, the present Mikado (or Emperor) of Japan, was born in 1852 and succeeded his father in 1867. His reign has been marked by great reforms, including the abolishment of the feudal system. Under his enlightened rule Japan has advanced to a position in the East analogous to that of England in Europe, and is a marked contrast to the weak and fraudulent manner in which public affairs are conducted in China. Mutsuhito has given the Japanese a parliamentary constitution based on European principles, civilization has made rapid progress, and the introduction of western arts and ideas has secured for Japan a foremost place among the Asiatic nations.

Tsai-Tien Hwang-ti, the Emperor of China, was born in 1871, and in 1887 took the nominal reigning authority. In 1889 he took control of the government. The government of the country is in theory most carefully organized, but in reality it is most corrupt. The viceroy Li Hung Chang, the Bismarck of China, is said to be worth $500,000,000, some of which he will certainly be relieved of to help pay the enormous war indemnity which Japan will impose as one of the conditions for a cessation of hostilities. For our engravings we are indebted to the Illustrated London News.

ARGON—A SUGGESTION.

By G. JOHNSTONE STONEY, M.A., D.Sc., F.R.S.

IN the examination of argon we are still at the stage of being engaged in the search for what it really is; so that it is not useless at this stage to set down all the possible alternatives.

And first, with respect to the ratio of the specific heats and what it implies, viz., that the energy of the "internal" motions—of motions within the individual molecules—is small. There is, as regards this, another alternative besides those presented at the meeting of the Royal Society, which is that the mass of the molecule may consist of a large mass comparatively quiescent and a small mass in active motion. In this case, as well as in those stated at the meeting, the energy involved would be small, and we should, moreover, have a state of things very much more consonant with the fact that argon emits two complex and bright spectra.

Such "internal" activity involving little energy is not unknown. It is, in fact, what occurs in the familiar phenomenon of phosphorescence, where a body has had such motions set up in some part of each molecule as are capable of emitting light for a long time, but which are so isolated from the rest of the molecule that they do not share their energy with it so as to raise the general temperature.

It may be objected that if the molecule consist of one predominant mass associated with one or more small masses, the predominant mass will absorb energy by rotating; but this is based on the supposition that it is a rigid body. Now we must remember that, though this conception of rigid bodies is so much the most convenient to the mathematician that it is universally adopted in the dynamical investigation, nevertheless such bodies are impossible from the physicist's standpoint, and do not exist in nature. Who that considers the connections can doubt that a molecule of the normal paraffin C_8H_{18} which may be represented by—

```
  H H H H H H H H
H·C·C·C·C·C·C·C·C·H
  H H H H H H H H
```

is more like a long flexible thread than a rigid sphere? Now, it is easy to conceive that at the close of an involved struggle between two such molecules protracted over a time which is long when compared with other molecular activities, the conditions may be such when they part that they will sail off from one another without much rotation having been set up. Where we are misled is by the false analogy of rigid bodies, and especially by thinking of the prolonged encounter that takes place in nature with all its complex incidents, as a mere collision!

To return to our illustration. It is quite conceivable that during the journeys of such a molecule as that of the vapor of the above paraffin between its encounters, the two end atoms, or the parts of them which carry their electrons,* may be swinging about violently, while the rest of the system travels along without much internal agitation.

This particular illustration has been selected because it seems possible that by the discovery of argon we have been brought within grasping distance of a much greater discovery; in fact, that it may in reality prove to be a compound of one of the six missing elements which lie between hydrogen and lithium—perhaps a compound somewhat like the above paraffin.

Assuming George Darwin's account of the origin of the moon, we must presume that as the moon and earth cooled down they evolved similar atmospheres, but that the potential of gravitation on the moon is too small to have enabled it to prevent the occasional escape of molecules of water, nitrogen, oxygen, and carbon dioxide; so that it has now been left without its atmosphere.

In a discourse delivered before the Royal Dublin Society on December 19, 1870, the present writer called attention to this explanation of the non-existence of atmosphere on the moon, and pointed out the fact that these gases having been able to escape from the moon, involves as a necessary consequence that a body with the earth's potential of gravitation and velocity of rotation must be unable to prevent the escape of free hydrogen from its atmosphere. Hence we should have now no hydrogen on the earth were it not for the circumstance that hydrogen entered extensively into combination with other elements, and thus forms part of molecules too massive to be able to escape from the earth. The earth, in fact, is only able to hold its large stock of hydrogen as constituents of such compounds as water, ammonia, hydrochloric acid, of organic substances generally, and of some minerals. But, except in a state of combination, the earth is not competent to retain hydrogen.* The six other elements between hydrogen and lithium seem not to have been able to enter into, or to remain in, combination under the conditions that prevailed at some stage of the earth's past history, and so then escaped—unless, possibly, a compound of some of them may yet be found.

Let us, for convenience, name them as in the accompanying Mendeleeff table.

Hydrogen	Infra-beryllium	Infra-boron	Infra-carbon	Infra-nitrogen	Infra-oxygen	Infra-fluorine	
Lithium	Beryllium	Boron	Carbon	Nitrogen	Oxygen	Fluorine	
Sodium	Magnesium	Aluminum	Silicon	Phosphorus	Sulphur	Chlorine	
etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.

Argon, then, may turn out to be a compound of one of these; and of them the most probable is perhaps infra-carbon. Silicon shows a slight aptitude for combining with hydrogen, and the hydride of silicon is a very active body. Carbon forms with avidity compounds with hydrogen that are so inert that one great series of them has been called "paraffins," from parum affinis. If this property is as much more intense in infra-carbon than in carbon, as it is more intense in carbon than in silicon, it may well result in producing a compound as impassive as argon.

Assuming that the atomic weight of infra-carbon is about two and one-half or three, then if it forms compounds similar to those of carbon, argon may be analogous to one of the paraffins C_7H_{16}, C_8H_{18}, C_9H_{20}, or to some other hydrocarbon of the fatty series, or to hydrocarbons of the benzene series, or to such compounds as naphthalene, $C_{10}H_8$; diphenyl, $C_{12}H_{10}$; turpentine, $C_{10}H_{16}$. It may even, though with less probability, be analogous to a monatomic alcohol, such as $C_4H_9.OH$ or $C_5H_{11}.OH$, or to some other compounds, and its inertness may be such that even substitution derivatives may be very difficult to produce.

A mere speculation such as this is only allowable under circumstances like the present—while we are feeling about for what argon really is. In one respect argon behaves very differently from the organic compounds of carbon, in that it is not decomposed by heat. This seems a natural consequence of the fact which has been brought to light by the ratio of its specific heats, viz., that but a small part of its heat energy takes the form of events going on within its molecules. Besides, infra-carbon is quite as likely to approximate to silicon in some of its properties as to carbon. But, above all, the hypothesis that argon is a compound has this great recommendation, that it does not involve any interruption of Mendeleeff's law, which, though only empirical, is probably true. The writer, therefore, hopes that this alternative possibility will be investigated along with the other, and perhaps less probable, ones that were produced at the meeting of the Royal Society.—Chemical News.

[Continued from SUPPLEMENT, 1002, page 16016.]

EXPLOSIVES AND THEIR MODERN DEVELOPMENT.†

By Professor VIVIAN B. LEWES.

LECTURE III.

ALTHOUGH the idea of smokeless powders for warfare has always been a dream with strategists, it is only within recent years that they have become an absolute necessity, as with the introduction of quick firing and machine guns into the navy it became necessary to have a powder giving little or no smoke, if the guns are to be of any use for the objects for which they were intended. For instance, in repelling the attack of torpedo boats, the use of black powder would entirely defeat the purpose of the guns, as after the first few shots the cloud of smoke would entirely obscure the whereabouts of the attacking force, and render for some time, at any rate, the further use of the guns abortive.

The formation of smoke during the combustion of powder is entirely due to the presence among the products of combustion of solid compounds, which, although liquid at the time of explosion, rapidly solidify as the temperature falls, and with the black powders, potassium carbonate, potassium sulphate, and potassium disulphide are the products which cause the fouling of the gun and, together with condensing water vapor, form the dense cloud of smoke which follows the firing of a shot. When using brown powder, although the smoke cloud appears at first to be as dense as with the black powder, it is noticed that it clears away far more rapidly. This is due to the fact that whereas the products of combustion of the black powder only contain 12·8 per cent. of water vapor, the products, of combustion from the cocoa powder contain 38·5 per cent. of water vapor, which in condensing carries down with it, by absorption and solution, the finely divided potassium salts.

The fact that the solid residue from powders consists entirely of potassium compounds from the base of the potassium nitrate employed in powder naturally suggested the idea of using some nitrate which would give up its oxygen for the combustion of the carbon and sulphur in the same way that saltpeter does, but should have as its base some body which would yield volatile or gaseous compounds. The only inorganic nitrate which would in any way answer this requirement is ammonium nitrate, and many attempts have been made to utilize this in forming a smokeless powder.

Unfortunately, however, ammonium nitrate is a highly deliquescent body, which has the property of so readily absorbing moisture from the atmosphere that the powder made with it would rapidly be converted into mud if exposed to atmospheric influences.

In order to obviate, as far as possible, this difficulty, F. Gans conceived the idea of replacing only a certain proportion of the potassium nitrate in the gunpowder by ammonium nitrate, imagining, by so doing, the hygroscopic character of the ammonium salt would be got over, while the formation of a volatile compound, called potassium amide, caused by the union of the potassium with the nitrogen and hydrogen of the ammonium, would occur, and, being volatile, would render the products practically smokeless, and in view of this theoretic action he christened his compound "amide powder." His views, however, were founded upon considerations which have not stood the test of practice, as the powder so produced was hygroscopic, and by no means smokeless.

The most successful attempt to produce a smokeless powder by the use of ammonium nitrate was made by Mr. Heidemann, one of the original patentees of cocoa powder, whose large knowledge of powder making and the requirements to be observed enabled him to so modify Gans's idea as to obtain a powder which not only gave most excellent ballistics but which was decidedly less hygroscopic than the ordinary ammonium nitrate powder, and gave but little smoke. This powder, like the cocoa powder, contains a certain definite amount of water as one of its constituents, and with a comparatively dry atmosphere shows no tendency to absorb more, but with a saturated atmosphere it rapidly shares the fate of the ammonium nitrate powders generally, and becomes pasty. In order to overcome this defect, the cartridges were inclosed in hermetically sealed metal cases, so as to prevent any absorption taking place, but it was found that the storage of these in ships' magazines—which, as I have pointed out before, are liable to become unduly heated—caused the moisture already present in the powder to become unequally distributed in the cartridges, with the result that there was occasionally a want of uniformity in the action of the powder in the firing, and a tendency to the occasional development of high pressure, and it was considered that this was a drawback to its adoption in the naval service.

In 1886, the attention of European powers was attracted to the acquirement of a satisfactory smokeless powder, and it appeared probable at that time that in France such a powder has been obtained for use in the Lebel magazine rifle.

When Schonbein discovered guncotton, it seemed at first as if the question of a smokeless powder had been solved, but as soon as experiments came to be made, it was found that on account of its low density it occupied far too large a volume, while when it was rammed into cases, the explosion was often of so violent a character as to produce disastrous results. Many attempts were made by Von Lenk to obviate this trouble by converting cotton threads into guncotton, and winding these threads with different degrees of tightness, generally upon a core of wood, but this system of taming the explosive power of the guncotton proved unreliable, and although Von Lenk's system was introduced on a somewhat extensive scale, the unsatisfactory results obtained soon led to its abandonment.

Von Lenk's results having been investigated by Sir Frederick Abel, the experiments were repeated in England with wound cartridges of guncotton threads, but with no better results than had been obtained in Austria, and Abel having in the meantime completed the improvements in the manufacture of compressed guncotton disks, attempts were made to use these built up into cartridges with varied air spaces, with the object of regulating the rapidity of explosion. No certainty in results could, however, be obtained, and the attempts to utilize it were for the time abandoned.

About this period Messrs. Prentice, of Stowmarket, and Colonel Schultze, in Prussia, had succeeded in making practically smokeless powders for sporting purposes. The Stowmarket preparation consisted of felt-like paper made of a mixture of guncotton and ordinary cotton containing 30 per cent. of guncotton and 10 per cent. of ordinary cellulose, together with oxidizing bodies, made in sheets which were afterward rolled up into the cartridges. This cartridge depended to a great extent on the presence in it of moisture for the ballistics which it gave, the unchanged cellulose being itself hygroscopic, and aiding hygroscopic action in the guncotton. It was impossible, however, to regulate the amount of moisture present, and when the cartridges had been kept in a warm place the moisture would become too low and the danger of detonation of the guncotton would increase, while if the cartridges had been kept in a damp place they were apt to burn more like squibs than explosives.

When this trouble was realized, the rolled cartridge was replaced by a cylindrical pellet of slightly compressed guncotton pulp, attempts being made to tame down the rapidity of the explosion, and also to waterproof it by impregnating it with a certain proportion of india rubber, but neither of these cartridges gave sufficiently uniform results to fulfill service requirements.

The Schultze powder on the other hand consisted of granulated wood which, after purification by boiling with dilute sodium carbonate, was washed and treated with a solution of bleaching powder; the mass was then washed, dried, and soaked in the mixture of strong nitric and sulphuric acids for two or three hours, the temperature at the same time being kept as low as possible, and after getting rid of the free acid in a centrifugal machine, the nitrated wood was washed with water until free from acid, boiled with dilute sodium carbonate, and dried, after which it was steeped in a solution of the mixed nitrates of barium and potassium, and again dried at a low temperature. This powder attained a considerable popularity for sporting purposes.*

Another powder which became very popular for sporting purposes was the well known E.C. powder, which was first made by Mr. Reid in 1882, and consisted of guncotton incorporated with 35 to 40 per cent. of the mixed nitrates of barium and potassium, the mass

* Electron, the fixed charge of electricity, the same in all cases, which is associated with each chemical "bond."

* The same method applied to Mars leads to the conclusion that it is improbable that the vapor of water can be retained by that planet, in which case we must look to some substance of greater density, such as carbon dioxide, as the material which produces the snow caps and the long streaky fogs (probably following valleys) which are from time to time seen upon Mars.

† Four lectures recently delivered before the Society of Arts, London.—From the Journal of the Society.

* Slight modifications have from time to time been introduced into the manufacture, and even within the last year I believe hardening of the surface by treatment with ether and alcohol has been resorted to.

being granulated and gelatinized by means of mixtures of ether, alcohol, and benzolene, which gave a hard coating to the grain. In this powder the presence of guncotton constituted a source of trouble, as the action was occasionally unduly violent, and the hard coating resisted ignition by the flash, and necessitated the use of a powerful cap.

In 1888, the E. C. powder No. 2 was introduced by Mr. W. D. Borland, and in this powder the use of true guncotton was entirely done away with, the nitrocellulose being completely soluble, and the hardness of the grain was obtained by treatment with a solvent containing camphor, which acted uniformly throughout the mass, while it left the surface in a slightly roughened condition, which enabled the flash to rapidly ignite the powder.

These powders gave very satisfactory results for sporting purposes, and also gave good ballistics with smooth bore guns, but both the E. C. and Schultze powder left an ash which was considerably harder than that afforded by the old black powder, and which instead of forming a partial lubrication for the succeeding shot, tended to choke rifled guns, so interfering with accuracy in shooting. Moreover, these powders could not be made on a large scale with a sufficient degree of uniformity to fulfill the requirements of service powders.

None of these powders were absolutely smokeless, as the inorganic nitrate used to supply the oxygen necessary for making up the deficiency in the nitrocellulose always gave a certain amount of solid residue, but the amount of smoke given varied a great deal with the kind of nitrate used, the presence of potassium nitrate in the original powder undoubtedly making the smoke much denser than when other metallic nitrates were substituted for it, this being one of the reasons why barium nitrate is employed to replace some of the potassium nitrate in these compounds, and also, of course, because the barium nitrate slows down the combustion.

It is not at all clear in the minds of many experts in sporting powders that an absolutely smokeless powder is any very great advantage over a powder which gives a small initial amount of smoke, which will condense or disperse with sufficient rapidity to enable the marksman to see whether his shot has struck the object aimed at; and the different rate of dispersion of various kinds of smoke renders smoke photographs, which have been somewhat popular of late, rather misleading, as upon the moment at which the photograph is taken will very largely depend the intensity shown by the smoke cloud. For instance, when firing two kinds of powder, at the moment of explosion the smoke given by each may appear to be identical in the photograph, while a second photograph, taken half a second later, may show one cloud of smoke to be many times denser than the other.

In this way it would be perfectly easy to prepare a photograph of the smoke produced by the firing of a charge of black prism and S. B. C. powder which would make the latter appear to give but little smoke, simply because of the lasting power of the products of combustion from the black powder and the rapid condensation and dispersion of the products from the cocoa powder, owing to its high percentage of readily condensable water vapor.

It has been shown that the compression of guncotton causes it to burn much more slowly when ignited under ordinary atmospheric conditions, and it was in this direction that all the early experiments tended, but it was soon found that in the chamber of a gun the pressure forced the flame first formed into the interior of the mass and produced detonation, which, giving no time for overcoming the vis inertiæ of the projectile, threw an enormous strain on the gun, and gave very unsatisfactory muzzle velocities. Many attempts were then made to so dilute and tame the guncotton by admixture with inert or less explosive substances as to render it sufficiently slow for this purpose, but with little success, as inequality in ballistics and the risk of detonation always remained an insuperable objection.

The first important step toward doing away with these troubles was the realizing that the cause of them was in the hollow fiber of the nitrated cotton, and that no matter how thoroughly the guncotton was disintegrated in the hollander during manufacture, or how closely the pulp was compressed in pressing the cartridges, disks or slabs, you had merely shortened the tubes, and had not done away with them, and that it was only by absolute destruction of the structure of the cotton that the too rapid combustion could be checked and the risk of detonation avoided.

Trinitrocellulose is soluble in ethyl acetate and nitrobenzene, while some other substances will convert it into a gelatinous mass, and by utilizing such bodies to absolutely destroy the structure of the cotton, and by converting it into a solid substance, which can only burn regularly from the surface, the rate of combustion can be controlled and the risk of detonation overcome. This method of taming the explosive has made the modern smokeless powder a practical possibility.

The fact that, with properly made powders of this character, surface combustion only takes place can be amply proved by the fact that if the powder be in any particular shape, such as strips or cubes, and the combustion is checked before it is completed, even when fired from a gun, the residue will be found to have the same shape as the original, reduction in size only having taken place, while if large masses of such powders be ignited, they will burn away fiercely but without the cumulative action which in ordinary guncotton would result in explosion.

In May, 1890, a fire took place at the ballistite factory at Avigliana, in Italy, and over twelve tons of this powerful explosive, consisting of nitroglycerine and nitrocellulose, took fire; the whole quantity burnt away in a few moments without explosion, and with only slight damage to the manufacturing plant, while, had the explosive ignited been unaltered guncotton or even gunpowder, a most fearful disaster would have resulted.

The adoption for service purposes of small caliber rifles and long cylindrical projectiles has given rise to the necessity for smokeless powders for military purposes, of a different class from those which have proved successful for sporting purposes, and the French government was one of the first to adopt a smokeless powder for use with the Lebel magazine rifle. The composition of this powder, called the "Vielle" powder, or "Poudre B," was shrouded in extreme mystery; but it is now an open secret that it contained, as its chief ingredient, picric acid, which was also the basis of that much-talked-of explosive, "melinite."

Picric acid, which was originally made by the action of nitric acid upon indigo, is now prepared far more cheaply by the action of nitric acid at a low temperature on carbolic acid and some other derivatives of coal tar.

Phenol, or carbolic acid—C_6H_6HO—is one of the compounds obtained from heavy tar oil, and is much used as a constituent of disinfecting powders and liquids. It crystallizes in needle-shaped crystals, possessing a strong tarry smell and has a fusing point of 42° C., the liquid boiling at 182° C.; and when a small quantity of the fused acid is poured into nitric acid, a violent action takes place, with evolution of red fumes. When this action has moderated, some of the strongest nitric acid is added, and the liquid boiled, until red fumes nearly cease to be evolved, and, on cooling, a yellow substance, called picric acid, crystallizes out, and can be purified by recrystallizing from water.

The change which takes place during the action of the nitric acid upon the carbolic acid may be represented as follows:

$$\underset{\text{Phenol.}}{C_6H_5OH} + \underset{\text{Nitric Acid.}}{3(HNO_3)} = \underset{\text{Picric Acid.}}{C_6H_2(NO_2)_3OH} + \underset{\text{Water.}}{3(H_2O)}$$

Picric acid may be regarded as a nitro-substitution product, in which three atoms of the hydrogen in the original phenol are replaced by the radical NO_2, and by the action of picric acid on metals or metallic bases is obtained the class of salts known as picrates,

$$\underset{\text{Picric Acid.}}{C_6H_2(NO_2)_3OH} + \underset{\text{Potassic Hydrate.}}{KHO} = \underset{\text{Potassic Picrate.}}{C_6H_2(NO_2)_3OK} + \underset{\text{Water.}}{(H_2O)},$$

many of which salts have the property of exploding when heated or struck.

Picric acid is a pale yellow crystalline solid, having the form of plates or prisms, and being but little soluble in cold water, although readily soluble in alcohol. It derives its name from its intensely bitter taste, and, for this reason, has been used in some hop substitutes for bitter ales. It is extensively used as a dye for silk and wool, which it colors a fast yellow.

On heating the crystals of picric acid, they fuse at 122° C., with partial sublimation, and explode at a slightly higher temperature.

When exploded, the decomposition is somewhat complicated. Nitrogen, carbon dioxide, carbon monoxide, nitric acid, water vapor and hydrocyanic acid are produced, and a residue of unburnt carbon left behind; an inspection of the formula for picric acid makes it at once evident that there is clearly not nearly enough oxygen for the complete combustion of the carbon and hydrogen present, and for this reason nearly all the picric powders and explosives consist of mixtures of picric acid and its salts, with oxidizing substances of a character suitable for supplying this deficiency.

It is now more than twenty years ago since Designolle first introduced potassic picrate and saltpeter for use as bursting charges for torpedoes and shells, and this was improved upon by Sir Frederick Abel, who substituted ammonic picrate for the potassic salt, the same composition also being adopted in Bruge's picric powder. Soon after this Dr. Sprengel showed that picric acid by itself was capable of being detonated by mercuric fulminate, and in 1885 E. Turpin patented the use of picric acid for shells and torpedoes, and proposed to make it less sensitive to percussion by melting it and pouring it while hot into the shells, or by making the grains into a solid mass by means of collodion, and in this way a very great weight of the explosive can be got into a small space on account of the high specific gravity of the fused mass.

Melinite contains picric acid as its chief constituent, mixed with some oxidizing substance, or, as stated by some authorities, merely made into a compact mass with collodion, and the explosive "lenite" is practically the same substance.

The "Poudre B" was in the form of small yellowish brown tablets of the thickness of a sheet of note paper, and about one-tenth of an inch square, evidently produced by cutting up thin sheets of material, but it was apparently adopted with undue haste, for promising as the first results appeared to be, yet powders of this description are lacking in stability, this fact being clearly shown by experiments which were carried out at Woolwich at the same time that the stir in military circles was being caused by the exaggerated reports of the success of the new French explosive.

Since that time the smokeless powders which have been introduced for use in the small caliber rifles may be classified under two headings:

1. Those consisting of nitrocellulose gelatinized, with or without the addition of nitrobenzene.

2. Those consisting of nitrocellulose gelatinized with nitroglycerine, to which have been added aniline, camphor, vaseline, and other substances of the same kind.

To the first class belong the B. N. powder manufactured by the French government, which consists mainly of gelatinized nitrocellulose, as also does the German Troisdorf powder, the surface of which, however, is coated with graphite.

Rifelite, made by the Smokeless Powder Company, apparently consists of nitrocellulose made from woody fiber, and gelatinized by acetone and nitrobenzene, while the sporting powders made by this company are of much the same character.

The Russian smokeless powder is also nitrocellulose, converted into a horn-like mass by a suitable solvent, and the German small arm powder is of much the same character, camphor also being used.

Two powders of this class are made in America, one being "Indurite," in which insoluble nitrocellulose is gelatinized with nitrobenzene, and the second the "Dupont powder," of much the same composition, granulated by a special process.

The methods by which the conversion of the powder components into the finished explosive is attained vary considerably, but in most cases the processes are simple, and consist in first kneading together the nitrocellulose with the solvent in a machine of the same character as those used in large bakeries for kneading the dough. These consist of iron cases, in which shafts rotate carrying screw blades revolving in opposite directions, which causes thorough incorporation and kneading of the substance placed in them. This operation might at first sight appear fraught with some danger, but the mixture of the nitrocellulose with the solvent is practically non-explosive, so that there is no risk unless actual flame is brought in contact with the mass.

The length of time taken in the kneading process varies from three to ten hours, according to the mass of solvent which is employed, a larger quantity requiring far less time than when only a small quantity is used. When this kneading and incorporation is completed, the mass has a soft consistency, and is generally semi-translucent, and is then ready for moulding into the form of the finished powder. In some cases the mass is converted into grains by suspending it in hot water and blowing steam into it, which disintegrates the mass and causes it to become granular. In other cases it is squeezed into threads or rolled out into sheets.

The largest proportion of the powders are made in this latter form, the kneaded mass being rolled out into sheets by means of rollers heated by steam, so as to drive out from the mass the solvent, at the same time that the thin sheet is produced, the temperature employed of course depending upon the boiling point of the solvent liquid. These sheets are then cut up into small squares or pieces of the required size in a cutting machine, while if the powder is required rather in the form of cubes than in flat flakes, several sheets of the explosive are superimposed upon one another and luted together by means of a fitting cement, and the mass is then cut into the required size.

This is necessary, as if the sheet were originally made of the required thickness, it could not be obtained uniform in density, and would always contain a number of air bubbles, while at the same time the solvent could not be properly eliminated.

Perhaps the most startling discovery with regard to explosives that has ever been made was when Mr. Alfred Nobel, who has done so much in the history of explosives of all kinds, showed in 1875 that when the two most powerful of the compound explosives were blended together, their properties became beautifully tempered, so that although the power of doing their full meed of work was still retained, the violence of the action was so far reduced that they became applicable for purposes for which neither of them alone could have been employed.

He found that when nitrocotton is thoroughly saturated and digested with nitroglycerine, the cotton loses all trace of its fibrous quality, and absorbing the nitroglycerine, becomes converted into a gelatinous body having almost the character of a compound. The nitrocotton, macerated with 90 per cent. of glycerine, and the mixture being kept warm, causes the formation of a plastic material from which neither of the components can be easily separated, and this substance, which has become of world-wide repute as a mining explosive, under the name of blasting gelatine, will always be regarded with even greater interest as being the parent of the best of the modern smokeless service powders.

In January, 1888, Mr. Nobel took out a patent for using nitrocellulose mixed with nitroglycerine, with or without the addition of a retarding agent, to form a powder which could be relied upon for use in guns.

It had been found by experiments made in Austria for putting blasting gelatine to military purposes, that this substance might be exploded by the penetration of a bullet or fragments of a shell into the transport wagon; and Colonel Hess, while endeavoring to make it less susceptible to accidental explosion, found that by incorporating with the components a small proportion of camphor, and also by increasing the proportion of nitroguncotton used, the rapidity of the explosion of the material could be reduced, and the product made of a horn-like character, which had remarkable ballistic properties, and which was uniform and practically smokeless.

Some of the camphor, however, used in the substance remains in it, and this being volatile, its evaporation causes modifications in the ballistic properties of the powder, and attempts have been made to improve upon this by replacing the camphor by other substances which would play the same part as the camphor, and which would not have the same drawbacks.

The powder so made by Nobel, and known by the name of ballistite, is extensively used in Italy and Germany. As manufactured in Italy, it contains equal parts of nitrocellulose and nitroglycerine, with the addition of a half per cent. of aniline, and when used in the form of threads or cords is called "filite." The German ballistite contains a rather larger percentage of nitrocellulose, and the finished material is coated with graphite.

In making the ballistite, the original method was to absorb the nitroglycerine by the collodion cotton in a vacuum vessel, and having pressed out the excess of nitroglycerine, to warm the remainder in order to dissolve the collodion cotton, but a far simpler device has since been introduced by Messrs. Lundholm and Sayers, by which the solution of the nitrocellulose and the glycerine is rapidly brought about.

If the nitrocellulose be slightly moistened, its solubility in nitroglycerine is very greatly retarded, but if the nitrocellulose be suspended with nitroglycerine in warm water, and the mass then agitated by blowing air through it, the incorporation of the nitroglycerine and the nitrocotton takes place with considerable rapidity at a temperature of about 60°.

When the incorporation is completed, and the mass thoroughly gelatinized, a large proportion of water is removed by pressure, and the mass is then rolled into sheets under heated rollers, and cut to the required size of flake and dried in the usual way.

In these powders the collodion cotton (dinitrocellulose) is employed, as it was well known that nitroglycerine alone does not dissolve the trinitrocellulose; but while endeavoring to avoid slight imperfections which had been noticed in the behavior of the ballistite, Sir Frederick Abel and Professor Dewar found that if trinitrocellulose and nitroglycerine were mutually taken up by a liquid capable of dissolving them

both, on evaporating off the solvent the trinitrocellulose and the nitroglycerine remained behind in the most perfectly incorporated and gelatinized condition, and it is to this principle that we owe our English smokeless service powder, cordite, which contains 58 per cent. of nitroglycerine, 37 per cent. of trinitrocellulose, and 5 per cent. of vaseline.

Cordite could be perfectly well made by incorporating trinitrocellulose with nitroglycerine by aid of such a solvent as acetone, but the perfect freedom from any solid or liquid products of combustion during the explosion of such a mixture leaves the bore of the gun so clean that great friction is set up between the metal of the bore and the bullet, with the result that metallic fouling of the bore, due to abrasion of the bullet, and wear of the bore due to the same cause, take place, and it is chiefly to overcome this trouble that the vaseline or petroleum jelly is incorporated with the other ingredients, as it gives a thin film of solid matter in the bore and greatly reduces this trouble, besides giving the cordite the power of resisting water and facilitating the squeezing of the material into threads.

The guncotton employed in the manufacture of cordite is made at Waltham Abbey by the same process as described in the last lecture, the only difference being that no lime water, caustic soda, or whitening is added in the last "poaching," and after moulding the pulp is only subjected to a pressure of about 40 lb. on the square inch, and, after the process, still contains about 40 per cent. of moisture, which is afterward "stoved" down to 0·5 per cent. If the guncotton had been pressed as in making torpedo slabs, under a pressure of 4,000 lb. to the square inch, it would have been too dense to have been afterward properly acted upon by the acetone and nitroglycerine in making the cordite.

After the guncotton has been dried in the stoving house at 100° Fah., it is taken to the nitroglycerine store in a covered trough, and the right proportion of nitroglycerine is poured upon it, and the two substances lightly mixed by hand so as to insure complete absorption of the nitroglycerine by the guncotton.

The mixture is now taken to another house, where it is put into a kneading machine, in which slowly revolving blades incorporate the solvent acetone with it, and keep it thoroughly mixed and kneaded while the solvent action is proceeding. As this action approaches completion, petroleum jelly or vaseline is added, and the whole charge is incorporated in the machine for seven hours, and is then ready for pressing. Strong gun metal cylinders are charged with the mixture under low hydraulic pressure, and these cylinders are then placed in position in the pressing machine, where a rammer of steel driven by a screw presses upon the mixture and drives it out through a small hole in the bottom of the cylinder as semi-gelatinous cords or threads of the required size. As these leave the machine they are supported on a running web, and cut automatically into required lengths, which are arranged for drying in shallow trays. The smaller sizes are wound on large reels, and when these are filled with the cordite they are, like the larger sizes, taken to the drying house and exposed to a temperature of 100° Fah., which drives off the acetone and renders the threads tougher. The finished cordite is now blended by mixing a number of batches together, and the substance is then ready for making into cartridges.

Acetone, which is used in making the cordite and also as a solvent in some other smokeless powders, is a compound having the formula C_3H_6O. It is a colorless, fragrant liquid, having a specific gravity of 0·81 and boiling at 56·3° C. or 133·3° Fah. It is inflammable, and burns with a luminous flame, and will mix with water, alcohol, and ether. It is essential for purposes such as the making of smokeless powders that it should be as pure as possible, as any traces of impurity would probably be left behind on its evaporation and remain in the powder. That used at Waltham Abbey has a specific gravity of 0·7965, and 98 per cent. of it distills off between 56·2° and 56·4° C. When such acetone is treated with a 0·1 per cent. solution of potassium permanganate, it should retain its rose color for more than two minutes, and the Waltham samples will generally do so for nine. In addition to this point, it should not have more than 0·005 per cent. of acidity nor contain more than 0·1 per cent. of aldehyde. Vaseline or mineral jelly used is obtained during the distillation of petroleum, and consists mainly of portions distilling at temperatures above 200° C.; it has a boiling point of about 278° C., and has been given the formula $C_{16}H_{34}$. Cordite burns when ignited in air and leaves no residue, and gives practically no smoke. It is not nearly so sensitive to percussive detonation as guncotton, though perhaps a little more so than gunpowder, and is so difficult to ignite in a gun that a primer of R.F.G. black powder has to be employed. When a rifle bullet is fired into cordite, it burns quietly.

It is unaffected by both frost and salt water, but when exposed for any length of time to the latter, it is better that it should be washed with fresh water and carefully dried at a temperature below 100° Fah. before being stored.

It has undergone several climatic trials which have so far proved satisfactory, the severe cold of a Canadian winter and the heat of an Indian summer having failed to shake the stability of the composition or to sensibly alter its shooting powers, while the cordite returned after these severe trials showed, on analysis, no alteration in composition, and it has now been passed as a service store with the proviso that the magazines are properly ventilated, and that the temperature does not rise above 100° Fah., conditions which, as I have already pointed out, should also be observed with black and brown powders, and could be perfectly well complied with on board ship by water jacketing the magazines, or even by surrounding them with a double bulkhead, the spaces between which could be packed with silicate wool or other non-inflammable non conductor.

The erosion caused by the use of cordite in small caliber guns is not appreciably greater than with powder, but as the size of the gun and the charge increase, the erosion becomes more marked as far as the first few calibers from the powder chamber are concerned.

The erosion caused by cordite is of a totally different character from that due to powder, the surface appearing to be washed away smoothly by the gases and not pitted and eaten into as with powder, so that efficient obturation of the shot can always be obtained by suitably shaped driving bands. The erosion also extends over a much less surface than with powder.

As regards the ballistics obtained by the use of cordite, the results of experiments made up to the present time are most satisfactory, and the following comparative table, which shows the pressure and muzzle velocities obtained from powder and cordite respectively, speaks for itself, and shows that the use of cordite enables a far smaller charge to be employed, and gives a large increase in muzzle velocity without corresponding increase in the pressure in the gun.

Powder.	Gun.	Charge.	Velocity.	Pressure.
Powder	Magazine Rifle.	71·5 grs.	1,830 ± 50	19
Cordite	"	31 grs.	2,000 ± 40	15
Powder	12-pr. B. L.	4 lbs. S. P.	1,710 ± 20	15
Cordite	"	1 lb.	1,680 ± 20	14
Powder	4·7-in. Q. F.	12 lbs.	1,786 ± 20	16 to 17·6
Cordite	"	5 lbs. 7 oz.	2,185 ± 25	15
Powder	6-in. Q. F.	29 lbs. 12 oz.	1,882	15
Cordite	"	13 lbs. 4 oz.	2,200 ± 25	15

There is a considerable amount of misunderstanding as to the action of cordite in guns. It is observed that certain velocities are obtained with particular guns with less chamber pressure with cordite than with powder, and the erroneous conclusion is come to that the pressures must be higher in the chase, but this is not the case. The reason that the cordite gives the higher velocities with lower pressure is that it has less work to do.

It must be clearly borne in mind that not only the projectile, but also the products of combustion, have to be expelled from the gun, these latter having ultimately even a higher velocity than the shot, and in using black powder the weight of the charge is far greater than with cordite. In black powder, also, fifty-seven per cent. of the charge is inert, whereas in the case of cordite the whole is operative, and gives the charge a great gain in efficiency over the black powder.

Through the kindness of the director general of ordnance factories, Dr. W. Anderson, F.R.S., I am enabled to give a curve, representing the pressures given by the cordite, as compared with gunpowder, in the six-inch guns.

The smokeless powder being of comparatively new manufacture, and only dating back a few years, it is unreasonable to suppose that it should be faultless in every respect, and there are still many considerations which will have to be studied by the light of practice before anything approaching finality will have been reached.

The products of combustion given by all such powders are far richer in carbon monoxide than the products evolved by the old powders, and we have yet to see what the effect of this will be in the turrets and fighting decks of our warships when in action, as it is a perfectly well ascertained fact that a half per cent. of this gas in the atmosphere renders it fatal to those who breathe it, but the probabilities are that it will be no more harmful than the old powder, as with breechloading guns only a small proportion of the products of combustion will find their way inboard. So far, however, no complaints have been received, either from the army or navy, of any inconvenience caused by the products of combustion.

The most that we can do at present is to strive for the attainment of the best results, and by carefully comparing the effects obtainable with various forms of smokeless powders, to see which of them attains most nearly to success, and to consider thoughtfully the indications given by such comparative tests in indicating the lines of research most likely to lead to ultimate perfection in our service explosive. It must be borne in mind that with our wide possessions, stretching into every variety of climate, where explosives have to be stored for many years, stability of composition is of the utmost importance, and has been the rock on which so many powders offered to the government, and apparently excellent as propellants, have made shipwreck.

The researches of Messrs. W. McNab and E. Ristori, brought before the Royal Society this year, are a most important addition to our explosives literature in this direction, and with their permission I am enabled to give a table showing the results which have been obtained, not only as to the relative value, but as to the products of combustion evolved in the explosion of the various smokeless powders now most largely used, and I think the lesson to be drawn from these results is that we may be justly proud of our service explosive, which was founded on the principles first practiced by Mr. Alfred Nobel, and perfected by the labors of Sir Frederick Abel and Professor Dewar.

Name of Explosive.	Calories, per gram.	Permanent gases, c.c. per gram.	Aqueous vapour, cc. per gram.	Total volume of gas, 0° C. 760 m.	Per cent. composition of permanent gases. CO_2.	CO.	CH_4.	H.	N.	Co-efficient of potential energy.
E C powder, English	800	420	154	574	22·9	40·6	0·5	15·5	20·5	459
S S, Sporting	799	584	150	734	18·2	45·4	0·7	20·0	15·7	586
Troisdorf, German	943	700	195	895	18·7	47·9	0·8	17·4	15·2	844
Rifleite, English	864	766	159	925	14·2	50·1	0·3	20·5	14·9	799
B N, French	833	738	168	906	13·2	53·1	0·7	19·4	13·6	755
Cordite, English	1,253	647	235	882	24·9	40·3	0·7	14·8	19·3	1,105
Ballistite, German	1,291	591	231	822	33·1	35·4	0·5	10·1	20·9	1,061
Ballistite, Italian and Spanish	1,317	581	245	826	35·9	32·6	0·3	9·0	22·2	1,088
Nitroglycerine	1,652	464	257	741	63·0	—	—	—	*33·0	1,224
Nitrocellulose, N 13·30 per cent.	1,061	637	203	876	22·3	45·4	0·5	14·9	16·9	929

* Also contains 4 per cent. oxygen.

SOLUTION OF SOLIDS IN VAPORS.

By P. Villard.

The author states that the results obtained by Raoul Pictet (C. R., Jan. 14, 1895) present a close agreement with his own relating to iodine dissolved in carbonic anhydride (Journal de Physique, Series 3, vol. iii., Oct., 1891). He adds that the absorption spectra in his observations, whether of the liquid or the vapor, presented in no case the flutings characteristic of gaseous iodine. Hence the latter seemed to be in a state of true solution in the vapor, even if not saturated.—Compt. Rend.

A NEW ELEMENT.

Dr. Bayer thinks he has discovered a new element among the by-products left after the extraction of aluminum from red bauxite. The liquors contain chiefly sodium carbonate and sulphate, together with chromic, vanadic, molybdic, silicic, arsenic, phosphoric and tungstic acids, as well as alumina, magnesia, lime, etc. The supposed element exists in the liquors in the form of an acid, which is soluble in water and forms yellow crystals. The solution is not precipitated by sulphureted hydrogen, but may be obtained on evaporating its solutions as a bluish-violet oxide, which subsequently becomes further oxidized and lemon-yellow in color. The latter compound, which probably corresponds to the formula R_2O_5, has marked acid tendencies, and forms characteristic compounds with different bases. The spectrum of the new body exhibits characteristic lines in the green, blue and violet, and it is suggested that Dr. Bayer has discovered one of the missing elements predicted by

Mendeleeff in the nitrogen-phosphorus group.—Bull. de la Soc. Chim.

ON THE LIQUEFACTION OF AIR.

[A note communicated by Prof. George Davidson.]

THE recent remarkable experiments of Prof. Dewar in liquefying air, etc., recall the experiments of Perkins in 1822–1826, as detailed in a paper of the Royal Society read June 15, 1826 (p. 541).

Mr. Perkins describes the apparatus which he had devised and operated, and says: "This tube [of steel] I filled with water and subjected it to a pressure of 2,000 atmospheres. After repeating this experiment a great number of times, the average of the result showed that the column of water, 8 inches long, was compressed ⅜ of an inch, or 1/21 part of its length. . . .

"With the same apparatus I also made experiments on the compression of other fluids. The most remarkable result I obtained was with concentrated acetic acid, which, after compression with a force of 1,100 atmospheres, was found to be beautifully crystallized, with the exception of about 1/8 part of fluid, which, when poured out, was only slightly acid. . . .

"As it might be supposed that even glass was pervious to water by such a force [500 atmospheres], a small phial was made airtight by fitting into its neck a well-ground glass stopper. It sustained pressure of 500 atmospheres without change and was perfectly dry within, although it remained under that pressure 15 minutes. It was next subjected to a pressure of 800 atmospheres, and when taken out was found to be crushed to atoms.

"In the course of my experiments on the compression of atmospheric air, by the same apparatus that had been used for compressing water, I observed a curious fact, which induced me to extend the experiment, viz., that of the air beginning to disappear at a pressure of 500 atmospheres, evidently by partial liquefaction, which is indicated by the quicksilver not settling down to a level with its surface. At an increased pressure of 600 atmospheres, the quicksilver was suspended about ⅓ of the volume up the tube or gasometer; at 800 atmospheres, it remained about ½ up the tube; at 1,000 atmospheres, ⅔ up the tube, and small globules of liquid began to form about the top of it; at 1,200 atmospheres, the quicksilver remained ¾ up the tube, and a beautiful transparent liquid was seen on the surface of the quicksilver, in quantity about 1/200 part of the column of air. The gasometer was at another time charged with carbureted hydrogen and placed in the receiving tube with its mouth immersed in the quicksilver; it was subjected to different pressures, and it began to liquefy at about 40 atmospheres, and at 1,200 atmospheres the whole was liquefied.

"These instances of apparent condensation of gaseous fluids were first observed in January, 1822; but for want of chemical knowledge requisite to ascertain the exact nature of the liquids produced, I did not pursue the inquiry further," etc.

REMINISCENCES OF JOHN DALTON.

THE past year having been the 50th anniversary of the death of the great chemist and philosopher, John Dalton, F.R.S., a very fitting step has been taken by those in the neighborhood of his native village in the erection of a memorial tablet to mark the humble cottage in which he was born.

By way of supplement to this movement, the following particulars about the early surroundings of John Dalton have been compiled, so that after the lapse of another half century a reliable account of the places associated with his youthful days which are at present in existence may be available for the future generation of chemists. It is desirable that at the very outset due acknowledgment should be made to Mr. Youdale, of Cockermouth, a distant relative of John Dalton, to whom we are indebted for certain local particulars, as well as for the loan of his private and authentic photographs, which are here for the first time reproduced.

Apart from Lancashire being the center of the chemical industry, it is a matter for additional and justifiable pride that Dalton was essentially a man of Lancashire. Though born at Eaglesfield, a small village near Cockermouth, in Cumberland, the most eventful portion of his life was spent in Manchester, to which city he came when 27 years of age. Moreover, his surname was, according to his own showing, of Lancastrian origin, Dal-ton being derived from Dale-town, a village in Lancashire. It is also interesting to know that he came of artisan and not yeoman parents, his father having been a weaver; though on his mother's side the yeoman stock of which she came can be traced several generations back.

The actual date of his birth was not known, no record of the event having been made by his father in the Quaker register of births. As a child, birthdays were unknown to him, and consequently when in later years he became famous, it was only by careful and laborious inquiry that the date recorded on the memorial tablet was arrived at. In this connection it is interesting to recall the fact that the case of John Dalton is not an isolated one. The date of the Duke of Wellington's birth has always been uncertain as far as the precise month is concerned, while the date of Voltaire's advent was likewise lost in obscurity.

His early youth was passed helping his father, as soon as he was old enough, by holding spools to prepare shuttles and such like.

As a youth he was by no means bright, being undemonstrative to a degree both at work and play.

The first evidence of mental capacity, above the ordinary, for a country lad of ten, was his unaided solution of the difference between sixty square yards and sixty yards square, a point which had been the subject of a dispute between two laborers. The dogged perseverance by which he conquered this first problem is characteristic of the man throughout his life. This propensity is further strikingly illustrated by another incident which occurred a few years later, and which is related by Dr. Lonsdale in his life of Dalton. Occasionally Dalton's higher faculties were tested by a Mr. Robinson, who was encouraging him in self-culture by setting him an algebraic problem.

Once on such an occasion, the problem being rather harder than usual, Mr. Robinson inquired after an hour if he had solved it. "No," said Dalton, "but yan med deu't" (one might do it). At bedtime, Mr. Robinson repeated his former interrogation, to which Dalton replied: "I can't deu't to-neet, but mebby to-morn I will." He went home and slept over it, and in the morning attacked the problem with a renewed vigor that brought the desired solution.

When all but seventeen John Dalton left his native village and went to Kendal. Here he kept a school for some time with his brother. In 1793, however, he came to the New College, Manchester, to teach mathematics and natural philosophy.

The portrait of John Dalton that we have been enabled to produce is a copy of the authentic painting which was looked upon by his friends as being the most representative and truthful, in that it gives as true a conception of the man as it is possible to gain from an inanimate picture. It represents him in the neat Quaker attire in which he was invariably dressed. To judge from his hat, which by the way is still in the possession of the Manchester Philosophical Society, it is evident that Dalton's head was of the brachycephalic type. In this respect he bore a singular resemblance to Sir Isaac Newton, and, according to Mr. Woolley, of Manchester, when a cast of Newton's head was placed near Dalton after his death, the resemblance was even more striking. In his general demeanor and scientific methods, however, he was more to be compared to his eminent contemporary, Gay-Lussac. His literary attainments were not great, though he worked out a new system of English grammar.

He had a sort of contempt for what is generally known as "genius" and always contended that whatever he had achieved beyond the ordinary was the result of arduous and unrelaxed application, coupled with an indomitable perseverance. That in after life he fully recognized these qualities as the groundwork of his success there can be no doubt, and he never missed an opportunity of expressing this opinion. The following anecdote instances this somewhat forcibly: Entertaining a friend and his son on one occasion, he inquired of the son about his studies and progress. After some conversation on the subject, he tersely remarked: "Thou seems to have better talents than I possessed at thy age; but thou may want the thing that I had a good share of—perseverance."—Chemical Trade Journal.

JOHN DALTON.

THE MINIMUM TEMPERATURE OF VISIBILITY.

A RECENT paper by P. L. Gray describes experiments made upon a strip of platinum with the object of determining the minimum temperature at which it becomes visible in the dark. The author refers to the paper by Draper* as giving the only exact results upon the subject. He shows that Draper's temperature of minimum visibility, corrected by recent determinations of the coefficient of expansion of platinum, becomes 490° C., instead of 525°, and is not very much above his own determination given below. Furthermore, Draper's conclusion that all solid bodies become visible at the same temperature is fully confirmed by the author's observations with bright and lampblacked platinum.

In order to determine the temperature of the platinum strip Gray used a modified form of Joly's meldometer,† consisting essentially of a strip of very thin platinum about 10 cm. long, 1 cm. broad and 1/50 mm. thick, placed in a vertical plane. In regard to its use the author says:

It can be heated by an electric current, and its linear expansion is indicated by an optical method, by which an alteration in temperature of 1° can easily be noticed. The method of calibration is described in Joly's paper, and in that already mentioned, so that it is unnecessary to do more than briefly refer to it here. Minute fragments of substances of known melting points are placed on the strip and watched through a microscope, while the temperature is very slowly and cautiously raised until, in any case, melting is seen to take place, when the position of the spot of light which indicates the expansion of the strip is noted. In these experiments the substances used were K_2NO_3 (339°), AgCl (451°), KBr (699°), and gold (1,041°). From these observations a curve showing the relation between temperature and scale readings is obtained. . . .

Method of Making the Experiments.—The first requisite was to get the strip in a perfectly dark inclosure, within which both eyes could be directed toward it without strain. To this end the apparatus was inclosed in a wooden box (blackened within), one end of which was replaced by a black velvet cloth, under which the observer placed his head, and which he could gather round his neck and under his chin, so that not a ray of light could penetrate the inclosure. The box was about 48 cm. long, 30 broad and 22 high, and ordinarily the eyes, in making an observation, would be about 30 cm. from the strip. The other end of the box was provided with a hinged shutter, which was lifted immediately after an observation had been made, for the purpose of noting the temperature of the strip.

The strip itself was further protected from draughts, etc., by means of a piece of brass, bent twice at right angles and resting on the slate block below the strip, as in the calibration experiments. The angular dimensions of the surface of platinum, as seen in any experiment, were therefore:

Apparent length = 3° 40′ approximately;
" width = 1 54 "

so that the apparent area subtended was about 36 times that of the full moon.

The current by which the strip was heated ran through a variable carbon resistance, the handle of which was within convenient reach of the observer as he sat with his head under the black cloth. He could thus alter the temperature of the platinum until it was on the very verge of invisibility, a very small fraction of a turn being then sufficient to produce utter darkness where before the area of faint light had been. A contact breaker was also within convenient reach, so that the current could be broken or made at pleasure, and the objective reality of the faint luminosity at the limiting point thus demonstrated. When he was satisfied that the limiting point had been reached, the hinged end of the box was opened, a beam of light sent to the mirror connected with the strip, and the deflection, giving the temperature, read on the scale. The possible error in the estimation of the absolute value of the temperature may be taken as certainly not more than 2°. . . .

The general conclusions reached are as follows:

(1) That the minimum temperature of visibility is the same for a bright polished metallic surface as for one covered with lampblack, although the intensity of the radiation in the two cases may be different.

This result may at first be, to some, unexpected, but a little consideration will show that it might have been, à priori, anticipated. For probably temperature governs the highest wave length from a radiating body, and wave length governs visibility, at least after an extremely small intensity of radiation has been passed.

(2) That the visible limit at the red end of the spectrum varies greatly for a normal eye, according to its state of preparation, i. e., according to the intensity of the light in which the observer has been before making the observation. . . .

Speaking generally, we may say that a bright light diminishes the sensitiveness of the eye to radiation of low frequency; that darkness increases it. Or that, as a rule, the eye is less sensitive in the morning than at night.

(3) That for the less sensitive condition, the minimum temperature of visibility for the surface of a solid is about 470° C., but that this may be much reduced by even a few minutes in a dark room.

(4) That at night, a surface at a temperature of 410° is visible, and that by resting the eyes in complete darkness, this may be reduced to as low as 370° nearly, below which apparently one cannot go, since ten minutes' rest appears to be almost as efficacious as three hours.

(5) That different people's eyes (of no special or known departure from normality) differ somewhat in their "minimum temperature of visibility," but probably not to any great extent, if tested under the same conditions as to preparation, etc. . . .

The loss of distinct color at the low temperatures is very striking; the appearance to the author and to most of the observers has absolutely nothing of red in it, but is like a white mist—the nearest comparison that can be made.

In the morning observations, however, when the strip disappeared at from 460° to 470°, the last appearance was distinctly reddish; and this agrees with one observation noted at night, when, after getting the visibility critical point at about 390° C., the temperature was raised until one could declare for certain that the light looked red; it was then found to be 449°.

Of course, in all the observations, the luminous area was most distinctly seen by somewhat averting the gaze from it; generally it was found best to look in the direction of either far upper corner of the inclosure.

As already mentioned, most of the observers pronounced the appearance at the critical point to be that of a "whitish mist;" one, however, thought he saw a slight "lilac tinge" in it; and "Case G" declared it to be decidedly yellow, which is interesting, because to him a red mark on white paper (such as a pip on a card belonging to one of the red suits of a pack) appears yellow by artificial light at night.

In one experiment a plate of glass, ½ inch thick, and in another a layer of water, ½ inch thick, were inserted between the strip and the eye, without making the slightest difference in the phenomena; showing (1) that the point where these substances begin to be more or less opaque to infra-red radiation had not been reached; (2) that the small difference in intensity produced by their insertion had no appreciable effect. This last conclusion is far more strongly borne out by the equality of temperature in the case of the bare metallic and the black surfaces, and indicates that in all the cases it was wave length, and not intensity, which was determinative of visibility, so disposing of the possible objection that the difference between "morning" and "evening" might be due merely to the state of enlargement of the pupil of the eye, which would naturally be more contracted at the one time than at the other, thus affecting the total amount of radiation falling on the retina. Also, if such an objection were valid, it would imply that fatigue of the muscles of the iris produced a relatively enormous "time lag" in following changes of luminous intensity, which we know does not exist.

There seems, in fact, to be little doubt that the difference is due to the retina itself becoming sensitive to long waves after rest, which were incapable of affecting it when it was in some way fatigued by exposure to the ordinary bright light of day.

The next and obvious step is to find the respective

* On the production of light by heat, Phil. Mag., xxx, 345, 1847.

† Proc. R. Irish Acad., III, ii, 38, 1891–92.

wave lengths corresponding to the different temperatures. This point, however, and others, cannot be determined without some additions to the present apparatus, and will form the subject of a future paper. —Proc. Phys. Soc., London, xiii., 122.

A SIMPLIFIED PHOTO-CHROMOSCOPE.

CARL ZINK, of Gotha, Germany, a well known German photographer, who is at the same time an ingenious mechanic, some time ago patented a coating apparatus, remarkable for its simplicity and practicability, and which proved a great boon to dry plate makers.

At the late meeting of the German Photographic Association, at Frankfort a. M., Herr Zink was again an exhibitor. Upon this occasion it was a simplified photo-chromoscope, by which, with aid of three positives, resulting from negatives made through the requisite color filterers, were reflected upon three surfaces, so as to appear, when viewed through a graphoscope or other suitable lens system, as one picture greatly magnified in the natural colors.

The extreme simplicity and cheapness of this instrument, combined with its practicability and superiority, at once brought it into notice.

By reference to the two accompanying cuts it will be

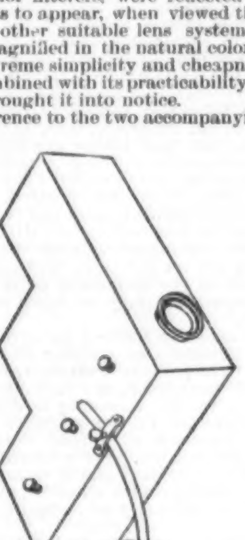


FIG. 1.

seen that all delicate adjustment and consequent danger of derangement are overcome. Further, that by the use of a large magnifying lens combination similar to the graphoscope, the image is viewed greatly enlarged, which is a great improvement over the microscopic eyepiece thus far used.

Fig. 1 represents the apparatus ready for use, the only object for the adjustment being the better to turn the images toward the source of light. No extra powerful illumination is necessary with this simple apparatus, as has been the case with similar apparatus thus far. It is stated that a clear diffused light is all that is requisite.

Fig. 2 explains the simple mechanism of the new

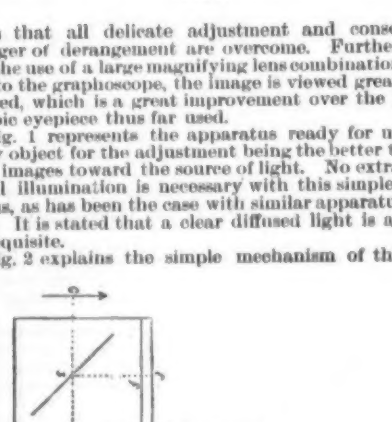


FIG. 2.

apparatus. A B C marks the position of the diapositive. F the red, E green, D cyanine blue glass respectively. 3 is a polished silver or platinum mirror, 2 and 1 ordinary sheets of polished glass that reflect the images from F D E toward H, where the colored rays are united.—Am. Jour. of Photo.

[FROM THE ASCLEPIAD.]

HEALTH AND ATHLETICS.*

By Sir BENJAMIN WARD RICHARDSON, M.D., F.R.S.

A STUDENT all my life, and still a student, I have the greatest pleasure, fellow students, in appearing before you to deliver, at your request—made through Mr. Francis Thomas—a lecture on "Health and Athletics."

I understand that you have been led to wish for this lecture from reading my address on the Athletic Life, lately delivered before the Birmingham Athletic Society, and published in Longmans' Magazine. It will be fitting, therefore, that this lecture should be a kind of expansion of that essay, and that I should endeavor in a plain and simple way—as student speaking to students—to deal with athletics in relation to health. I have always been a stanch advocate of exercises of a physical kind, my experience—I mean personal experience—having been from the earliest part of my life strongly in their favor. It is possible that some would say I had thrown away working time on physical exercises, and it is true I have given up many hours that might have been devoted to books on physical labors of a healthful and more recreative description, but I do not believe that I have ever, in the true sense, lost anything, because it has always seemed to me that by working with much more ease after good exercise, I readily made up the time that seemed to have been lost. More than that, I was not so sensible of fatigue from mental work after exercise as when I kept to the desk or the book more closely, and it is quite certain that the general health and nutrition of the body have been improved by the physical activity pursued. I am sure, therefore, I am not misleading any student in recommending him to combine good physical work with mental work.

I am sorry I have not a large number of facts of a direct physical kind at hand bearing upon various sports and exercises. My own exercises have been confined chiefly to walking, riding on horseback, bowls, cricket, and cycling, with an occasional touch of rowing, but not much of the last, and never in a systematic manner. At the same time, from great interest naurally felt in sports, and from a rather long life, I have come as largely into contact with athletes of various kinds as most men, and have indirectly learned a large number of practical truths. It is well I should tell you this, because you would not think much of a man who came down as a mere bookworm to talk to you about athletics and athleticism.

In the paper on the Athletic Life, the nature of that life as a special one is defined, and I do not care to vary the definition. The athletic life is in the main physical, and it is what its name implies, a physical contest. The term "an athlete" means a person who can boast of physical powers; who can wrestle, run, walk, swim, cycle, ride, fight—with or without weapons—play at active games, and, in a word, use his physical powers, not against ordinary men, but against men who claim similar athletic qualities. It seems to me that this life is a short one, running only from about 18 to 36 years of age, 18 years in all, the fifth part of one of the longest lives. But there is another kind of life, which though not strictly athletic, borders upon it. Every man is not born an athlete, but there are large numbers of men, and I may add women, too, who though they may not enter into competitions of a severe kind, are nevertheless capable of doing a great deal of first-class work. We may call these minor, or sub-athletes, and they abound in every large school and every university and college in the world. They in their way, therefore, come under similar rules to those laid down for athletes, and it is not necessary to alter the title of this lecture in order to include them within its teaching. My argument is that for all classes the physical school is a grand training school, and that it is good, even for those who are removed from actual athletic competition.

Before we pass to the special consideration of athletic exercises, it may be as well to direct attention in a general way to the advantages and disadvantages of them, for there are disadvantages as well as advantages connected with them.

THE ADVANTAGES.

The advantages of physical exercises consist in the cultivation of mental as well as physical skill. The physical body is better developed if exercises be properly carried out and be of the best kind. By them the form of the body is made more perfect; the vital functions are carried out with greater regularity and vigor, and the senses are rendered more acute and better able to carry out their important duties. The sense of sight is specially benefited by physical exercises; the muscles which move the eyeball are made to play with greater precision, so that the sweep of the sight is more rapid and more exact than it would be if good training were omitted; the eye also learns to see things near at hand and things far off with greater ease, owing to the accommodation that is given to adjustment of the lenses of the eye; and the power of sight is more steadily maintained. The sense of hearing is in like manner rendered more acute and perfect; sounds high and low are more distinctly appreciated, and the perception of the direction of sound, which indolent people rarely recognize without a particular effort, becomes an easy practice. The muscles of the body also become more obedient the one to the other in their respective functions; they develop well and gain strength in the development; and they act correctly in regard both to time and tune. The physician knows that in health co-ordination of muscles and of muscular movements, which exercise of all things brings forth best, is a sign of health. He sees mischief, on the other hand, marking error in the nervous system whenever there is a deficient co-ordination, sees in fact more or less of derangement, or it may be disease, of the nervous system. In persons who cannot be said to be actually ill, want of co-ordination is often a mark in itself of deficient physical development and exercise. They fail in the most ridiculous manner in the use of particular parts, just as the left hand—which from want of practice is often an indifferent hand—fails compared with the right. Under good physical training disadvantages of this kind speedily disappear, and one part becomes as able as another. I knew one of the sporting men of the old school in the early part of my life, who had a saying which illustrates this point exceedingly well. He used to say, "I wouldn't give twopence for a fellow who cannot fight with his left hand as well as with the right, or for a cock that cannot use the spur with both legs." Lastly, muscles that are well trained have more power for continued work. They are not easily tired, and they are recruited after a shorter rest than are muscles that are allowed to lie fallow, if I may so express myself. These are advantages purely of a physical character, and there are others of a mental nature which are equally valuable. The well trained man learns in a very short time to make up his mind as to what is best to be done on emergency. He discovers that to decide wrongly is better than not to decide at all, so that at last he becomes competent in an almost automatic manner to know at once what is the best thing to be done at any given time, and what is the most graceful and safest way to do that thing. There is not a single contest of physical skill in which decision is not called for at every stage, and decision demands at all times a wholesome mental training, based on correct foresight and sound principle. Decision is, in fact, quick reasoning in all struggles; it is tact in motion. Another good mental quality brought out by good training is that it leads to presence of mind. His physical movements and the direction of those movements demand all the attention of the athlete, so that external noises and interruptions shall not interfere with him or take away what is commonly called his presence of mind. He is deaf to external noises, and is acting for himself, abiding by his own judgment. Thus he is enabled often to perform acts and feats which other persons consider dangerous, and to outsiders appears destitute even of fear. "He is brave," say the outsiders; and it is true, for bravery is a great help, while fear is a disastrously catching disorder. A distinguished athlete who used to perform the most remarkable feats of strength and risk once told me, "No man in peril succeeds if he is in fear." He meant that fear increases danger and often generates it.

Good exercise combines mental with physical endurance, and those persons are most finely balanced in whom the mental as well as the physical powers are sustained together. There is strength of body and there is strength of will in the man well trained to physical exercises, and the will, to use a common expression, drives the mind. At one time I thought that perfect physical endurance is what is mainly required for successful physical action. I was wrong there. I would not contend that mental endurance can supply physical, that is not the case; but certain it is that the most splendid physical qualities are of little value unless they are backed up by mental ones which give the vital spur to successful effort. Combined they are all-powerful, and supply qualities of precision, decision, presence of mind, and endurance, which are among the most advantageous qualities any one can possess.

DISADVANTAGES.

So much for advantages. Now for disadvantages connected with athletic sports—for there are disadvantages, which ought never to be overlooked, but which ought to be as far as possible avoided when it is known what they are. I will put them fully forward therefore. There is a disadvantage in this respect, that sometimes, owing to faults in the training or to the selection of exercises that are not fitted for the body, or to injudicious efforts to excel, certain parts of the body are irregularly developed. We are aware of this irregular development by the circumstance that it may actually become visible to the eye. In the opera dancer, there may be undue development of the muscles of the leg; in the rowing man there may be undue development of the muscles of the arm; and in the cyclist there may be not only undue development of the lower limbs when the exercise is carried to an extravagant length, but, owing to the mode in which the body is bent over in the act of cycling, there is induced not infrequently a temporary deformity which may pass into a permanent one if it be permitted too long. Also, in some instances, from excessive exercise, the heart itself becomes enlarged, irregular in action, at first much too powerful, in the end too feeble. These are serious disadvantages, which creep gradually on, and often are not detected until it is too late for them to be remedied. There is another disadvantage which is more direct in its nature, that is, a dangerous degree of muscular fatigue followed by feverish condition, and followed again by a considerable exhaustion—precisely, in fact, as if the person had passed through a fever, so that physicians sometimes speak of the condition as "fatigue fever."

We have learned a great deal on this last point in the past few years. We have learned that unless the muscles have been brought into fair condition, not an over-condition, they are very susceptible to a change of structure, which is, in its way, actually dangerous, a sort of suppressed or subacute tetanic state called, commonly, rigidity, stiffness of muscle. The unconditioned muscle, in wearing out under exercise of an extreme kind, becomes incapable of natural movement, becomes painful, and produces in itself positive toxic or poisonous products, which have to be eliminated or thrown out of the body, and which act truly as poisonous products, causing fever and ultimate depression as a result of the fever.

I have more than once been called, as a physician, to see persons who have been suffering from this form of self-made disease, and I can assure you that it is not a disease to be considered trifling. In the lower animals we occasionally observe this disease from over-exercise attended with fatal results, as in the horse that is overridden, or in a smaller animal that is too severely chased. We see the disease specially in the human subject in young folks who are training too intently, and in those old who take up some exercise of a severe kind, such as mountain climbing or cycling, under the idea that they are going to renew their youth and strength. We find it again in those who are fairly trained when they are endeavoring to make their muscles what is called hard—like iron, as they boast, a condition which it is quite a mistake to consider good, and which has led to the saying by the training fraternity:

"Overtrain, overstrain;"

an excellent warning.

Fatigue fever has, unquestionably, many disadvantages. Once acquired it is easily repeated, and very often is repeated a second or third time from less disturbance than was created by the first invasion. Moreover, if it be severely felt it is a crippling agency, which, often repeated, disqualifies ever afterward for any supreme physical effort.

Lastly, there are disadvantages of a mental character which call for consideration. It is always bad practice to let exercise, and particularly competitive exercise, affect the mind too seriously. It is common for an enthusiasm of a most disturbing nature to connect itself with competitions. The mind becomes harassed with hopes and fears, loses its correct balance, and either is led to too exalted and hopeful an enthusiasm or to anxiety, fear, and depression. Each of these mental errors is apt to induce recklessness. The exultant man relies too much upon his powers, and goes wrong in that direction. The doubtful man thinks matters could not go worse whatever he did, and becomes rash from actual despair. In either case there is danger; and not a few go wrong altogether, and de-

* Lecture delivered before the Shaftesbury Club, Oxford, in the Clarendon Room, March 5, 1894.

sert their studies under these perturbations of mind. It would be possible to point out many other minor disadvantages connected with the cultivation of physical exercise, but I have named the major ones, and they are quite sufficient to accentuate the lesson which should be naturally drawn from them.

(To be continued.)

[FROM POPULAR ASTRONOMY.]

THE SPECTROSCOPE IN ASTRONOMY.

By TAYLOR REED.

A GREAT part of our knowledge of the sun has been gained by a study of the edge of the sun's disk. Here the conditions are changed. On the disk proper we have the incandescent interior, with its matter in a solid or liquid state possibly, more probably gaseous under high pressure; this interior shines through an outer layer of cooler gaseous matter under low pressure, which also may be incandescent. At the edge of the sun's disk we see this gaseous matter alone, with nothing brighter beyond it; and a shining gas gives a spectrum in which the lines are bright. Could the lines be seen thus bright or "reversed"? For hydrogen the answer was immediate: easily and always. For the other lines the reply is even yet in part uncertain.

The layer of hydrogen surrounding the sun is of some depth; as seen at the edge of the sun's disk wide enough at any point to be separately examined by the spectroscope. This "chromosphere" is 5,000 to 10,000 miles in depth, and the filaments of which it is composed are vertical. To be sure it can be seen for an instant at the time of a total eclipse. But if not absolutely, it is still almost entirely a spectroscopic creation.

At times of total eclipse it has been observed that just as totality begins many lines turn suddenly, for a second or so, bright. The moon in its progress before the sun has at that moment cut off all the bright interior of the sun, leaving visible only the cooler gaseous edge. Many lines are "reversed," as has been both observed and photographed. Are all reversed? Theory says they should be. Observation has not yet decided positively yes or no.

In an eclipse it is the moon that cuts off the light of all the sun but the edge, and so the obstruction is beyond our atmosphere. At ordinary times the slit plate of the spectroscope must be the screen, while the edge of the sun alone must be in the narrow slit. But the earth's atmosphere in its ceaseless moving churns the two parts of the image together; so that the observation such as is made at an eclipse of the edge alone with none of the interior, has probably never been accomplished. The most even suspected is that at one or two times of magnificent steadiness of air the lines have become as bright as the general spectrum; that is, the spectrum uniform, and this only a few times in the whole history of these observations.

But frequently there is found at the edge of the sun's disk a point or small region of disturbance; of motion as shown by displacement of lines, particularly of the hydrogen lines; or of pressure, as shown by thickening of lines. At such places lines are often seen "reversed;" sometimes many lines. Some lines are reversed only at the place of disturbance strictly. Lines of another class are reversed over a larger region, but still only near the point of disturbance; they seem to be half way between the other lines and the hydrogen lines. Of the second class some do not correspond with dark lines in the ordinary spectrum; perhaps none do. Those of the first class seem surely to be the dark lines reversed. But the various lines even of the same chemical element perform very differently. In all about 300 lines of all kinds have been seen bright; a few easily, but a good half of them rarely, and very faintly, brightened.

Prominences extending out from the edge of the sun were observed at total eclipses. Spectroscopists learned early that they could be observed at any time by placing the slit of the spectroscope at the edge of the sun over the prominence and opening the slit. If a hydrogen line be observed, the form of the prominence is seen. The existence of a prominence at any point is known by the brightening of a hydrogen line away from the exact edge of the sun. These prominences have long been the subject of study, as well as most easy and most pleasant observation. Their study is pleasant from the countless variety of form they offer, and from their rapid change of form. And their study is easy because with very limited equipment they may be superbly shown; better usually than with the giant spectroscope of a great equatorial.

Of classes of prominences there are two, differing slightly in chemical nature, utterly in form, and much in attendant circumstances: the quiescent and the eruptive or metallic.

Quiescent prominences are well described as to form as having the shape of a banyan tree. A mass of matter some distance above the sun is connected with the sun by one or more stems. Not infrequently the stems are absent, and the prominence appears as a cloud, entirely detached from the sun's surface. The markings on the prominence in any case are considerable, irregular and interesting. The change in appearance is sometimes so rapid as to be considerable in two or three minutes. Or, they will remain almost unchanged for hours. A change in form or size is not in general attended by motion toward or from us; in fact, such motion is not usual in quiescent prominences. Chemically they consist of hydrogen and an unknown and mysterious substance to which the name "helium" has been assigned. Their height varies from 10,000 to 150,000 miles; 30,000 being perhaps an average height. Their width is usually greater than their height.

The eruptive prominences are usually very small; most of them but a few thousand miles in height. When high they always take the shape of spikes or horns. The highest of them are far and away the highest of all prominences. The highest ever observed extended 400,000 miles from the sun's surface, a distance equal to a whole radius of the sun. They are called "eruptive" because violent motion usually accompanies them; particularly at the base of the prominence, as if there were an eruption. They are called "metallic," because some metallic lines are reversed at least at the bottom of the prominence, and occasionally for some distance above the sun's surface. Most eruptive prominences occur near sun spots; especially near young sun spot groups. Unlike the quiescent prominences, they show a decided preference for the sun spot zones.

In the spectrum of the sun's corona the one preeminent thing is a bright line in the green. The lines of hydrogen appear faintly as bright lines, and a number of lines in the extreme violet and ultra-violet. A faint continuous spectrum is shown, which may not be uniform in brightness throughout the spectrum. The spectroscope thus demonstrates, by showing these bright lines, that the incandescent matter of the corona is in the gaseous state; and that in it hydrogen plays a secondary part. The early observations indicated that this prominent bright line due to the corona coincided with a well-known line of iron; leading to the incredible result that the inconceivably rare corona was in some way due to heavy vapor of iron. But greater spectroscopic power showed that the line in question is double; and that one component is the iron line, the other that of the corona. Of what element is the corona then composed? In despair the answer is given of "coronium."

To our little knowledge of the corona the spectroscope thus contributes its mite; but still leaves it the sun's mystery. An analogy cannot fail to occur to the mind. The earth has its similar mystery, in the phenomenon of the aurora. Both exist above the surface, where any gas is very rare. Both have their beautiful streams. Each has a characteristic form in the neighborhood of the pole of its sphere. Apply the spectroscope to both, and the analogy is continued. Each gives in the spectrum an unidentified bright line, with fainter companions. Each shows a faint continuous spectrum.

At the present time work with the spectroscope on the sun continues active. In fact, work on the sun, and spectroscopic work on the sun, are synonymous terms; identical terms, except for important researches on the sun's heat, and some minor observations on spots. If the volume of information the spectroscope has given us of the sun is large, we cannot suppose it will be no larger. For if there is hope of advance in knowledge of the sun, it seems to lie in the spectroscope and in the bolometer.

[FROM THE STREET RAILWAY REVIEW.]

HONOLULU.

THE low lying isles of the Pacific, which for many years eluded the most careful search of the Spanish galleons, came under the spy glass of the great circumnavigator James Cook in 1776, and his greatest discovery was the Sandwich Islands, lying between north latitude 19° 22' and west longitude 155-161°.

In 1840 the thirteen islands, the principal of which are Hawaii, Oahu, Maui, Molokai, Lanai, Nihau, Kahoolani and Atuai, were united politically.

Topographically, the islands are most picturesquely beautiful, rising, as they do, volcanically from the bosom of the ocean of great peace, and diversifying between excoriated, lava-incrusted mountains and lovely verdure-filled valleys, teeming with all the tropic life of the latitude. The two great volcanoes, still smouldering, mountains Loa and Koa, have been already the subject of description and illustration, and are familiar to all, while the stranger can gain but little from any description of the magnificent scenery.

HONOLULU—KING STREET CAR IN FRONT OF GOVERNMENT BUILDING.

A day in Hawaii begins early with the first rising of the sun from the great ocean, until in the evening the sun sinks, without any warning dusk, into the bosom of the sea, whence it came.

During the rainy season it may pour for seven days, but dust will be flying on the eighth, so rapidly does the moisture sink into the porous coraline soil. Occasionally furious showers sweep across the islands, drenching everything and everyone on one side of the street without a moment's warning, and leave the other side of the thoroughfare laughing at their discomfiture and basking in the radiant tropic sunlight. There is nothing so brilliant, so inexpressibly bright, as the Pacific sunlight. The nights, with the almost electric moonlight silvering and witching the tropic landscape, is indescribably affecting. In the absence of moonlight, Honolulu calls into requisition myriad electric lights. The mauka, or mountain wind, is invigorating and conducive to health, but there is a southerly breeze, known among the natives as a "sick wind," while the trade winds blow; the air is usually invigorating for nine or ten months in the year, beginning in April.

St. Patrick is remembered in Ireland for his snake

SCENE ON MAIN STREET, HONOLULU, S. I.

exterminating piety, but not even the name is recorded of the Hawaiian deity who rid these lovely isles not only of snakes, but of every other vertebrate. The pigs introduced by the European residents were the largest animals seen by the natives for many years. Only a few varieties of birds are to be found on the islands, but articulates and insects by the million make up for the paucity of other living things. The flora of the islands is magnificent and varied. The cultivated plants growing without cultivation and towering palms, spreading banyans, bread fruit, algaroba, oleander, tamarind, monkey pod, alligator pear, traveler's tree and the hibiscus grow and flourish in profusion. Sugar cane, with its concomitant industries, is grown easily, and the manufactured product is the principal export of the islands.

The principal exports of the islands, besides the well known sugar trade, are rice, hides, bananas, wool, goat skins, betel leaves and coffee, although the entire group is rich in possibilities of all kinds. The kingdom exported 12,073,361 pounds of sugar of a domestic value of $344,231.61 during the last quarter of the year 1891. The value of exports may be largely increased, as capital and men go into Hawaii and the sister isles for trade and manufacture.

TRESTLE, TRAIN, PASSENGERS, AND FREIGHT, MAHUKONA RAILROAD, S. I.

NUUANU AVENUE, HONOLULU.

The islands have for many years been the resort of every class of invalid to whom a warm, even climate and dry sea atmosphere are beneficial. This in itself is a matter of no little importance to the inhabitants and of great benefit commercially. The ocean steamers which constantly ply the Pacific water waste bring thither patients suffering with all kinds of pulmonary and nervous disorders, to be recuperated under the bland influences of climate, people and food.

Taking Honolulu as a representative of the best that is afforded there, the stranger finds himself among a most hospitable people, and whether introduced or depending upon individual merit, is brought into a society that cannot be improved upon anywhere on earth.

Along the wide avenues, shaded by magnificent palms, are found the homes of Honolulu, embowered in vines of dark tropical greenness and surrounded by wide lawns of Bermuda grass.

These unpretentious dwellings, usually of one story of wood or stone, over which the blooming passion vine or bougainvillia cluster, are supplied with verandas on every side. The vines are usually brought over the lava driveways upon trellises, and every point shows beauty and bespeaks comfort.

The wide main piazza, or lanai, where wicker sofas, lounging chairs and hammocks rest the physical man, is the rendezvous of the household. On tables the latest magazines may be found to pass the time and keep the islander in touch with the world.

The public buildings are deserving of attention in their really luxurious appointments. The Royal or Iolani Palace is an imposing three-storied building of concrete, a favorite material in the dry climate, containing forty rooms and surrounded by a park of several acres. In the interior, to the right of the main entrance, is the throne room, an immense apartment hung with draperies of deep crimson and in which are the dais, the famous yellow feather cloak, which has covered generations of dusky monarchs, the crown and scepter, coat of arms and other insignia of the royalty that habitates the structure.

The population of Honolulu is 23,000, and with this number of cosmopolites come all the ordinary and some of the extraordinary conveniences of civilized life. For instance, protection against fire is assured by a fine fire department, with a chemical engine, assisted by two water torrents; an electric light plant supplies private and public places with the most modern illumination, and a system of street railways gives ready if not very rapid transit to the various points of interest.

Personally, the natives Hawaii are usually large and finely formed, inclined to stoutness, which is considered a beauty, with bronze-brown skin and black straight hair.

The males wear workingmen's dress, adding by way of ornament gay-colored bandana handkerchiefs and wreaths of flowers; while the women in calico holokus

and leis of peacock feathers, shell, beans or fragrant maile vines.

This love of floral decoration is one of the most distinctively Hawaiian customs, and pervades all ranks, ages and conditions of the native population.

The various religious denominations are well represented by almost every faith from Joseph Smith to the great Joss.

Education in Hawaii is at a high pitch of excellence. The islands have 178 schools, superintended by 368 teachers, 195 male, 173 female, and have a certified attendence of over 10,000 pupils; of these, over 9,000 are between 6 and 15 years of age; and of a total of 30,161 native male and female, over 6 years of age, 79 80 per cent. are able to read and write.

Higher education is supplied by Oahu College and Punahou Preparatory School.

These schools give a very fair working education, and among the wealthier classes of citizens the homes are supplied with American, English and French teachers.

The newspaper and the publisher are fixed and flourishing institutions in Hawaii.

Hotels are numerous and the accommodations good.

The other appointments of the city are not much variant from those of a city of the same size in California or Australia.

Steam railroads are in active and paying service on the islands of Oahu, Maui and Hawaii. The efficiency of the passenger service of the Oahu Railroad Company, at Honolulu, cannot be surpassed. We present an engraving of the Oahu road as it appears bridging the chasms that present themselves before the engineer.

The islands are fast becoming the most pleasant and popular tropical resorts in the world, and well may it be, for almost every visitor can say, with Mark Twain:

"No alien land in all the world has any deep, strong charm for me but that one; no other land could so longingly and beseechingly haunt me, sleeping and waking, through half a lifetime, as that one has done. Other things change, but it remains the same. For me its balmy airs are always flowing, its summer seas flashing in the sun, the pulsing of its surf beat is in my ear; I can see its garlanded crags, its leaping cascades, its plumy palms, drowsing by the shore, its remote summits floating like islands above the cloud rack; I can feel the spirit of its woodland solitude; I can hear the plash of its brooks; in my nostrils still lives the breath of flowers that perished twenty years ago."

HONOLULU—GOVERNMENT BUILDING, OPERA HOUSE, AND PALACE YARD.

WAIKIKI ROAD, HONOLULU, S. I.

INTERESTING DOCUMENTS IN THE BRITISH MUSEUM.

IN the bewildering maze of the British Museum, where many miles of shelves and cases are filled with world's treasures, there is one little room that attracts a greater number of visitors than any other. The crowds that throng about the cases in this room are composed of persons of curiously diverse characteristics. It is a center of interest for scholars and literary people, and yet seems as attractive to the least learned of the visitors. The room contains the department of autographs and manuscripts, and the treasures displayed in it are perhaps the most humanly interesting in the whole museum.

Here are all manner of writings by the hands of the world's great men of many ages and countries. There are personal letters of kings and popes, queens, ministers and courtiers, whose names in history, in story and in song seem not to stand for real men and women, but rather for legendary beings, and these reveal in some homely phrase or bit of simple sentiment a touch of human nature which seems to make them more akin to those who curiously scan the letters to-day. Here one may come, as it seems, to actual acquaintance with the most notable of the characters in Shakespeare's historical dramas and get a new reading, in the quaint original, of passages in his works.

Here are charters and state documents that tell volumes of history in a few lines; letters of the great religious reformers, of statesmen, generals, poets and composers. These autograph documents, many of them letters from husband to wife or lover to sweetheart, show famous personages in a very different light from that in which they are commonly seen in the pages of history.

There is one letter of George Washington's written when he was yet a colonel in the service of King George III. It is dated at Fort Cumberland, August 28, 1758, where he was then camped, in command of

the English troops engaged in operations against the French, and is addressed to Brigadier-General H. Bouquet. He complains of the inactivity, of which "we are all of us most heartily tired and sick," and says, "I could wish most sincerely that our rout was fixed that we might be in motion."

There are autographs of almost all the English sovereigns who have reigned in the last five hundred years. The signatures of the kings who figure in Shakespeare's dramas, together with many of the dukes, earls and nobles who walk the stage with them, are to be seen, and in many instances in documents that recall some of the most striking parts of the plays. "Richard Gloucestre," afterward Richard III; "Harre Bokyngham," the ill-fated Buckingham, and "R. Edwardus Quintus" are all on one slip of vellum, cut from a volume of state papers of the date 1483.

All the leading characters of Shakespeare's "Henry VIII" are represented by autograph letters. There is a letter from Henry VIII to "myne awne good cardinail," written in March, 1518, when Wolsey was at the summit of his greatness and in highest favor with the fickle king. "Surly yow have so substancyally orderyd oure maters bothe off thys syde the see and byonde," wrote the king, "that in myne oppynion lityll or no thyng can be addyd." He signs himself "your lovyng master, Henry R." Close beside this is a pathetic letter written by Cardinal Wolsey after his disgrace, dated March 9, 1530, to Stephen, afterward Bishop of Winchester, but intended for the king's eye, in which he says: "I trust yt wole now please his Maieste to shewe hys pety, compassyon and bowntuose goodnes towardes me without sufferyng me any leynger to lye langwyshyng and consumyng awey throwth thys myn extreme sorowe and hevynes." The letter is subscribed, "With the rude hand of your dayly bedysman, T. Cardinalis Ebor."

There is an affectionate, motherly letter from the wronged Queen Katherine to her daughter, the Princess Mary, expressing pleasure at the daughter's success in her studies, and telling her that "it shal be a grete comfort to me to see you kepe your Latten and fayer writing and all." It is signed, "Your loving mother, Katherina the qwene." Beside this is a letter from Anne Boleyn to Cardinal Wolsey concerning her coming marriage to Henry VIII, thanking the cardinal "for the great Payn and travell that your grace doth take in stewdying by your wysdome and gret dylygens howe to bryng to pas honerably the gretyst welth that is possible to come to any creatour lyvyng," and promising that "after this matter is brought to pas you shall fynd me, as I am bownd in the meane tym, to owe you my servyse, and then looke what thyng in this world I can immagen to do you pleasor in, you shall fynd me the gladdyst woman in the woreld to do yt."

There are two notable letters written by Oliver Cromwell, which show the great commoner in different lights. One is to Lord Fairfax, announcing the capture of Wexford, and in it he says: "The Lord shewes us great mercye heere; indeed Hee, Hee only, gave this stronge towne of Wexford into our handes." The other letter is to his "lovinge wife," in which, after speaking affectionately of several members of his family, he beseeches her to "Minde poore Bettie of the Lords late great mercae," and continues: "Oh, I desire her not only to seeke the Lord in her necessitye, but indeed and in truth to turne to the Lord and to keepe closse to him." The handwriting is small, clear and regular.

A curious pair of documents are counter proclamations by Lady Jane Grey and Queen Mary, both announcing their succession to the throne of England. The one by Lady Jane Grey is dated from the Tower of London, and requires allegiance against the "fayned and untrewe clayme of the Lady Marye, bastard daughter of our great uncle Henry th' eight." It is signed "Jane, the Quene." Mary's proclamation denounces "the ladie Jane, a quene of a new and pretie Invencion." There are other pathetic letters by Lady Jane, written from her prison in the Tower, all of which she signs "Jane, the Queen."

The one letter in the room written by Elizabeth is in French and was written wholly by herself, in long, thin, sprawling characters. There are also letters of a more or less private nature written by Charles I, by his son, Charles II, by Mary Queen of Scots, the Pretender, all the Georges and Williams, and most of the other English kings.

Of letters by famous persons other than royalties, having reference to important historical events, there is a wondrous wealth. There is the original letter written by Archbishop Cranmer to Cromwell, Wolsey's faithful servant, thanking him for obtaining the king's permission that the Bible should be publicly sold and read throughout the realm. Letters written by Martin Luther, John Calvin and Melancthon are also to be seen and read. There are personal epistles by Sir Walter Raleigh, Sir Thomas More, Michael Angelo, Albrecht Durer, Rubens, Van Dyck, Rembrandt, Bacon, Galileo, Sir Isaac Newton, Moliere, Dryden, Swift, Addison, Pope, Goldsmith, Sterne, Dr. Johnson, Boswell, Garrick, Kemble, Southey, Coleridge, Wordsworth, Lamb, Hood, Lytton, and very many other famous men.

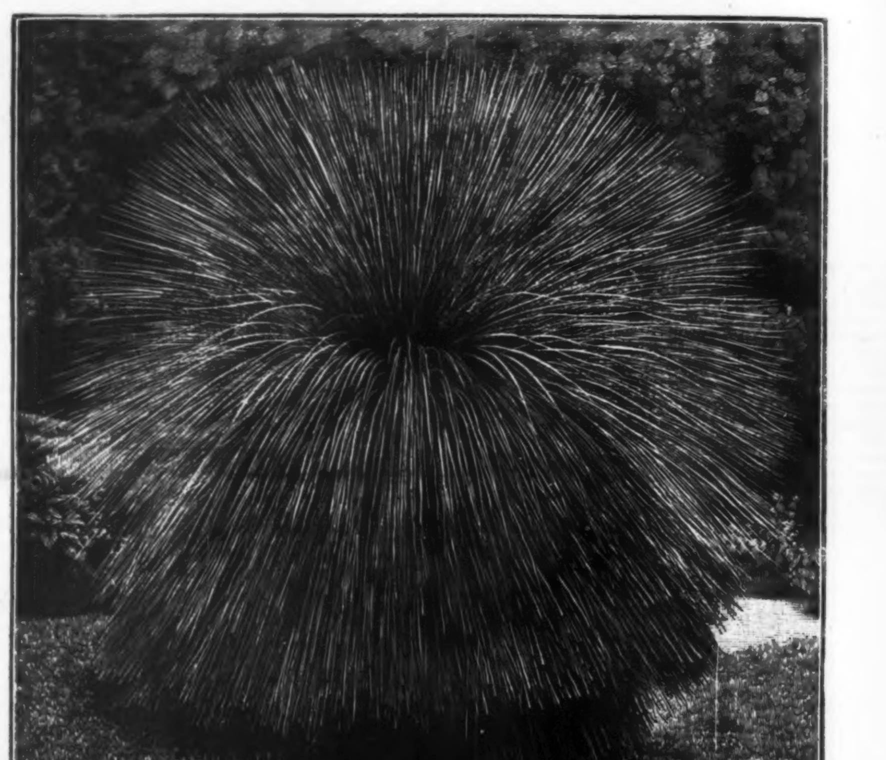
All the letters give in some way or another a revelation regarding the authors, and literary students visit the department day after day to read and reread the letters.

The collection of literary relics, as distinct from simple letters by famous authors, is especially interesting. There is the original agreement by which "John Milton, gentleman," sold the copyright of "a Poem intituled Paradise Lost," to Samuel Symmons, printer, for the sum of £5. This, however, was not the total amount he got for the poem. He received £18 from the sale of subsequent editions, making his pay £23. One of the three or four existing signatures of Shakespeare is also to be seen. It is attached to a mortgage deed, and is written "Wm. SHAKSPa." Milton's Bible, containing family records in his handwriting, is in a case near by. There is a volume of the original draft of Pope's translation of the Iliad and Odyssey, in his own handwriting, written for the most part on the back of letters addressed to himself. Other notable treasures are the original manuscript of Burns' song, "Here's a health to them that's awa," and Gray's "Elegy," some manuscript music by Handel, Haydn and Beethoven, and poems by Goethe and Schiller.

Of great generals and admirals, like Wellington and Nelson, documents associated with their most notable achievements are exhibited. There are shown the last letter written by Nelson, dated on board the Victory, on the eve of the battle of Trafalgar, addressed to his wife; and a letter by Wellington concerning the arrangements for the Peninsular campaign. Of the great statesmen, such as Pitt, Fox, Burke, Warren Hastings, Clive, Walpole, Hampden and Churchill, autograph letters connected in some way with their greatest work are to be seen.

The collection of historical documents, charters and the like is very valuable, reaching back to the time of Alfred the Great. All that remains of the Magna Charta, which was burned with many other documents in a fire in the museum in 1731, is preserved in a special case, to be seen only by special permission. It is the most precious of England's national heirlooms. The bull of Pope Leo X, conferring on Henry VIII the title of Defender of the Faith, a title Queen Victoria still holds, was almost destroyed by the same fire, but some of it yet remains.

Leaving the cases containing special letters of great men for those in which are preserved miscellaneous manuscripts, the visitor is simply dazed by the extent and value of the collection. The department contains more than 9,000 volumes of manuscripts written in Oriental languages, and each one is either a rare work in itself or representative of a particular type. There are more than a hundred ancient Greek, Coptic and Latin papyri, and 40,000 other volumes of various kinds. While most of these are interesting only to the scholar, many of the Oriental exhibits have a peculiar interest for the merely curious visitor. One Pali manuscript is engraved in beautiful characters on twenty-five leaves of silver. Another is written on lacquered palm leaves with inlaid letters of mother-of-pearl. Another is written on a sheet of gold, and others on ivory. The favorite material for this class of manuscripts is palm leaves, and some of the volumes consist of several hundred such leaves bound in covers of ivory.—N. Y. Sun.



GRASS TREE (XANTHORRHÆA HASTILIS), IN THE DURBAN BOTANIC GARDEN, NATAL.

THE GRASS TREE.

WE are indebted to our old and valued correspondent, Mr. Medley Wood, of the Natal Botanic Garden, for the opportunity of figuring the beautiful specimen of the grass tree in the gardens under his charge. The grass trees form the Australian genus Xanthorrhæa, which belongs to the Liliaceæ. The tall stems are like those of palms, and thickly covered with the remains of the old leaves cemented together by the brownish resin which exudes from the stem. The stems are often charred and discolored by bush fires. The developed leaves are very narrow, forming a thick crown at the top of the stem, gracefully curving downward, as shown in our illustration. The long scepter-like flower spike springs from the center of the tuft of leaves. The cut will show better than words the ornamental character of the plant. Unfortunately it is not hardy.—The Gardeners' Chronicle.

THE WARE COLLECTION OF BLASCHKA GLASS MODELS OF PLANTS AND FLOWERS IN THE BOTANICAL MUSEUM OF HARVARD UNIVERSITY.

THESE specimens, which were referred to in the last number of this journal, are now arranged with a degree of completeness which renders possible a general consideration of their origin and purpose.

In planning the arrangement of the botanical museum, the director was so fortunate as to secure the advice and cordial co-operation of Mr. Alexander Agassiz. In the preparation of the plans much prominence was given to the subject of a synoptic room, where the types of vegetable structure could be comprehensively displayed somewhat after the fashion of the zoological synoptic room. But it was early seen that dried specimens of flowers would be too perishable and alcoholic specimens too obscure to render useful any attempts in this direction by ordinary means. Drawings and paintings of flowers seemed likewise unsatisfactory. Models alone remained. Examination of the available models in papier mache showed that they would occupy too much space, and be possibly misleading in the qualities of texture and color.

It occurred to the present writer that the Blaschkas, the artists who had constructed the exquisite glass models of marine invertebrata and had distributed them from their studio and laboratories in Dresden to museums throughout the world, might be induced to try their hands at the preparation of models of flowers and leaves. A visit expressly for this purpose was made to Germany in 1886. It was only after much solicitation that the Blaschkas, father and son, were led to undertake the construction of a few specimens. These proved entirely satisfactory. They were so thoroughly promising in every respect that arrangements were made at once for the preparation of about a hundred selected types. The Blaschkas reviewed their botanical studies, always with them a favorite pursuit, and engaged in the new work with interest and uninterrupted success. In the case of the elder Blaschka the work was really the resumption of an undertaking begun at the instance of Prof. Reichenbach in 1866. The models which were then made were sent to the museum of natural history at Liege, Belgium, and were consumed in the destructive fire of 1868. Since that date no glass models of plants had been made by either the elder or the younger Blaschka their time had been fully occupied with the preparation of models of marine invertebrata.

The new undertaking was, of course, very costly; but this consideration did not deter Mrs. Elizabeth C. Ware and her daughter, Miss Mary L. Ware, of Boston, from authorizing extended contracts with the artists for their entire output of flower models. The subjects for study were carefully selected with reference to a complete representation of the chief types of structure in the vegetable kingdom, and these subjects were confined, where practicable, to the species found in North, South and Central America. Up to 1888 the generous patrons of the enterprise had not permitted their names to be known in connection with it, but it was now seen that the magnitude and beauty of the collection justified its designation as a memorial to the late Dr. Charles Eliot Ware.

The last contract with the artists bears date of 1890, and runs to 1900. The Phænogamia now on hand comprise 122 natural orders, 407 genera and 507 species. These figures indicate sufficiently that the subjects have been chosen with reference to the widest possible range of illustration.

Each plant model is accompanied by models of structural details, for the most part highly magnified. There are 2,160 of these details, making, with the large models, more than 2,600 pieces of glass work. The present rate of production is about 100 of the larger models and 500 of the minor ones each year. When it is remembered that all of this work is based on original botanical study of the species in hand, and is accomplished by two artists who carry on their modeling unaided by any assistants, the rapidity of execution must be acknowledged to be marvelous.

As Mr. Walter Deane has shown by his account of a minute examination of the Blaschka models of our Eastern plants, there is absolutely no flaw in the work-

manship. Every detail is given with perfect accuracy, and all are drawn to scale.

The subjects are supplied to the artists in the three following ways: (1) Plants which can be raised out of doors in the garden near the laboratory and studio are cultivated from seeds and roots sent from this country; (2) Central and South American exotics are freely furnished from the greenhouses of the Court of Saxony at Pilnitz, one mile from the studio; and (3) the economic plants of the tropics have been studied by Rudolph Blaschka during a recent journey made for that purpose. The sketches for these plants are among the most interesting features of the whole enterprise. They consist of accurate drawings of the whole plant and of microscopic details throughout, together with full records of impressions as to color. These multifarious sketches are supplemented by alcoholic and dried material prepared for the specific object of supplying all possible information regarding structure.

With the exception of a few specimens where the use of very delicate wire is needed, all the models are constructed of glass or a transparent enamel. In some instances the color is given to the glass before the model is made; in some cases mineral pigments are added after the completion of the form. In no case has there been observed the slightest change in color of the added pigments or in the character of the surface by exposure to light. It may be assumed, therefore, that these models possess a high degree of permanence under ordinary museum conditions. Since they are absolutely faithful copies of the specimens in hand, and since they undergo no change, they are valuable records of form, color and texture for future comparison.

In the case of American plants which are represented by identical species in the old world, the artists have been urged to employ, as far as practicable, the most typical specimens of the old world form. This has led to the conviction that in no case yet studied are the old world species exactly like ours. In a few instances the differences are sufficiently marked to justify the separation into two distinct varieties, and in two cases the differences would be interpreted as specific.

From the foregoing it will appear that the rapidly increasing collection at Harvard University Museum is of use not only to the public and to the students, but also to the systematist who is engaged in co-ordinating plant forms with a view to expressing affinities.

Further, it will plainly appear that these models are the best possible illustrations of the economic plants of the tropics, supplementing the alcoholic and dried specimens which are everywhere found.

The artists have already constructed some models to illustrate types of Cryptogamia. They have proceeded cautiously along this path, but their success is regarded by competent authorities to be assured. No specimen is allowed to leave their laboratory which has not been submitted to thorough examination as regards all possible points of doubt, and hence the illustrations of Cryptogamia will doubtless prove generally satisfactory. More than one hundred of these models are now in possession of the university, but they are not at present on exhibition, being withheld until the completion of the proposed series of types. With the exception of a few very large specimens, all of the models of flowering plants are now installed for exhibition.—American Journal of Science.

EXTREMES OF CLIMATE AND WEATHER PERIODS.

THE heat distributed to our earth by the sun is regarded as the great primary cause of the ever-shifting phenomena we term weather. By this means volumes of air receiving the greater amount of heat become rarefied and expand, and so, becoming lighter for any given measure of quantity, they rise in the heavier and colder medium and at the same time to a certain extent spread out, as they are relieved by ascension of the weight of the air left behind. At the same time a dynamic action results which was formulated by Espy, whose experiments indicated that the restoration of equilibrium after the reception of the force of the solar ray may be quite prolonged and complex in its progress.

Briefly, it may be stated that rising there is continued expansion of the heated volume as it comes under diminished outside pressure.

This expansion, as well as the colder medium above, tends to absorb the amount of heat at first lent by the sun, but according to the amount of vapor contained in the supposed measure of air, there is at the same time condensation of the former, offsetting to a certain extent by the resulting heat increment the lowered temperature due both to expansion and a colder environment.

This imperfect outline of an ingenious and generally accepted theory of a primary phase of atmospheric disturbance may illustrate the exceedingly complex relations and conditions that must, at the outset even, be accounted for if we discuss the problem of weather changes in general; a problem that considered at any point on the earth's surface must, it is obvious, estimate a host of variable factors between the equator and the poles.

If the ocean covered the entire planet, the problem of atmospheric circulation, though even then sufficiently complicated, would, as regards the elements of climate, be comparatively easy of solution. Then the fundamental equations might be kept within the limits of ordinary astronomical problems, and the origin and movement of storms could, perhaps, be traced a long time in advance with nearly the same facility as we calculate planetary movements.

But weather phenomena in general and in detail are closely related to the physical geography of our earth.

Obviously the various forms of relief, the mountain chains and table lands or plateaus and their slopes, the trend of valleys, the arid deserts and level or treeless plains and the form and position of the great continental areas relative to the oceans and their currents, each of these is not only to be regarded as an independent and constant factor in the mechanism of the weather, but incessant permutation of static relations consequent on dynamic action and interaction between constantly shifting centers of atmospheric disturbance compels the restoration of equilibrium in different instances by quite different modes, and through diverse paths of movement.

Evidently long range air currents continually flow out from equatorial to polar regions. It may be difficult to trace a continuous equatorial current to the most northern point of observation, but reactionary movements not infrequently traverse 2,000 miles or more in a nearly direct line from the Saskatchewan Valley to the further side of the Mexican Gulf. But in every case the dynamic action or amount of storm force developed is dependent on the presence of volumes of heated and moist air.

Herein we find both the material of the storm and the source of its tremendous energy.

This much is demonstrated and is in strict accordance with that most important generalization of modern science—the law of the correlation of energy or force. But to observe and follow the various transformations under this law that are continually at work in atmospheric changes is a matter of great difficulty—a problem not yet solved, not so much because it is not understood, as it is because the data remain beyond our reach.

Brief reference, however, to some obvious and probable conditions explanatory of extremes in the line of temperature, precipitation, and storms in general may be of interest. We have already noted that, beginning with the ascension of heated and moist air, and its movement toward higher latitudes, there results continue reactionary phenomena which all the time tend to enforce the equilibrium that has been disturbed, first by direct solar action, and second by a complex dynamic action that ensues. But the solar diurnal heat remains a constant factor through the entire chain of action, wherever its rays fall on land, water or cloud surface, causing by its maximum midday force the ascent of moisture into strata that resent the intrusion, at least as soon as the sun god weakens in power, and leaves, as he sinks below the horizon, the force born of his great fountain of energy to contend alone with the order of action that all the time tends to equilibrium by converting dynamic to potential energy. Rain and hail, the thunder storm and the tornado, are forms of action due directly to the midday diurnal movement, most active about three P. M., and outside the tropic zones. Following this maximum is the minimum of solar diurnal action, occurring between midnight and sunrise, when the upper cloud surfaces cool by radiation, from which a distinct class of storm action may ensue.

During some two years' residence near the Topajos River, at its confluence with the Amazon, about 2½° lat. S., the writer found that by far the greater amount of the immense precipitation of that region began daily at two to three A. M., ending, as a rule, between seven and ten A. M.

Midday showers or squalls about sunset were characteristic of the dry season (June to October), and these seemed most frequent near the coast at Para or about the elevated points below Santarem.

Thus it may be noted that the equatorial belt exhibits the phases of storm development to the final reaction so far as is obvious, by a limited circulatory system seldom if at all affected by polar air waves. But the temperate zone is continually the theater of conflict, under a variety of conditions of strong and far reaching air currents, both from tropical and polar areas. This action is especially exemplified in its most intense forms over the North American continent. The geographical features of all that portion of the United States lying east of the Rocky Mountains favor largely some climatic extremes.

The lofty mountain ranges near the Western coast isolate almost wholly the Eastern slope from the Pacific system. Only the lofty cirrus clouds and extensive fluctuations in pressure, as a rule, find their way across this great natural barrier. It has been shown, however, by General Greely in his valuable report on the climate of Texas, that during a certain period of the late summer and fall there is a direct flow of moist air currents from the Gulf of California to the trans-Pecos region in northwestern Texas.

In connection with this exceptional air distribution it occurs to the writer that this outflow may be rendered possible chiefly through the strong ascending currents of heated air from the Death Valley and Great California Desert region.

Some time in the future when, by the aid of suitably located observing stations, we become able to trace the diverse air currents that flow out from the great desert areas, the Sahara, the Siberian and others besides our own, is it not reasonable to hope we may find accounted for some extraordinary extremes of both temperature and precipitation? Evidently the arid volumes of air in question would be quite capable of producing continuous drouth wherever they might drift and hold possession. Might not the abnormal translation and permutation of currents from heated and parched areas account for such destructive drouths as have occasionally visited Ceara in Brazil, as well as other regions of our globe where the normal precipitation is ample? For it is quite possible that abnormal variations in any heated current flowing out from desert regions may produce an extreme of precipitation or its opposite; the former when by virtue of its heat energy it lifts and bears away as vapor, or even water itself, the material of a cloud burst or more gentle storm, the latter when with thirst unslaked from ocean or river it turns its breath of fire on field and vineyard, as happened on one memorable day in June, 1859, on the California coast.

Really the great natural features of the territory of the United States east of the Rocky Mountain Divide control, to a remarkable extent, as constant factors, the chief characteristics of American weather.

To any one desirous of understanding the ever-shifting phenomena of climate or storm movements a close study of our river systems and physical geography generally is an absolute necessity.

A casual inspection, even of contours of surface, and the land drainage in general from remote points north and west to the Atlantic, as shown on physical geography maps, will suggest valuable ideas as to the air drainage continually at work over this, the most remarkable area of conflicting equatorial and polar activity, perhaps, on the globe.

A wide expanse of nearly level and treeless plains between the Mississippi and the Rocky Mountains offers no obstacle to the flow of either gulf or polar currents. This is exactly opposite to the condition that obtains over a great portion of the European continent, where continuous action between the southwest and northeast winds is greatly impeded, or broken up, by transverse mountain systems.

In our own country comparatively low mountain ranges, together with a timbered region, as in Arkansas, partially modify the reciprocal wind action.

But a Manitoba blizzard finds little obstacle even in the Indian Territory during its sweep to the gulf, where it revels in new life and energy fed by an unlimited supply of warm and moist air. Yet a little farther eastward, as in southwest Arkansas, a genuine "norther" is of rare occurrence.

Still farther east, however, in the great river valley a pronounced type of "Texas norther" is not unusual at New Orleans.

In this way a cold wave moving east and south will vary its path, always seeking the line of least resistance. Temporary and variable factors operate, likewise, to produce deviations. Among such may be mentioned areas of high barometer, which, sometimes, by remaining stationary over certain districts of country, postpone indefinitely the advance of long range currents that would otherwise cause an opposite extreme in weather readings. Thus the December of 1889 remained almost throughout the month remarkably mild and free from storminess over the Southwestern States; this was attributed to the steady prevalence of unusually "high" and steady barometer from the gulf northward, the same being central over Georgia. At the same time the storm paths were all retired to much higher latitudes than usual.

As a chief factor determining the line of movement of cold waves General Greely remarks their tendency to follow the path of the last cyclonic area.

Judging from newspaper reports this might account for the decided southeasterly extension into Florida of the cold wave of December 26, 1894. Since that date up to the present, February 15, 1895, a cloud system apparently originating over the western gulf and moving eastward from the Rio Grande Valley has, at this point,* exhibited a remarkable contest with a constant succession of polar waves, all of unusual energy and magnitude. The apparent culmination of this conflict in one of the most severe and protracted blizzards known to south Texas appears to exemplify the existence of a twenty-five to twenty-seven day period, which the writer was, so far as he knows, the first to discover and define some forty years ago.

Such periodicity became specially obvious to the writer from a careful and continuous series of observations made at Ann Arbor, Mich., 1854-64 inclusive.

The periods in question seemed to define themselves as twenty-five day cycles nearly, and each included well defined weekly and semi-weekly terms, the last being a masked and subsidiary action of the equatorial type. All the terms were defined by characteristic types exhibited in cloud forms, structure and movement, as well as by the direction and changes of the surface winds. The accompanying curves of temperature and pressure were less clearly defined. I may remark that I never identified continuous periodic action through a longer time than six months. Furthermore such periodicity appeared most decided during the years marked by extremes of temperature and precipitation.

The years 1854, '55, '56 and '57 were all marked in this way by extremes of climate, and the recurrence of well defined weather periods, at least over the Middle Western States, and from reliable reports I judge such often extended from the extreme Northwest to the Texas coast. This was, I think, clearly apparent in the decisive storm movement that passed over all the United States east of the Rocky Mountains during the first week of September, 1854, and which closed a very definite type of weather that began early the preceding August.

The memorable blizzard of January 1, 1864, unparalleled throughout southern Michigan and generally over the Mississippi Valley for intensity and duration, was the close of a succession of monthly periods consecutive from the preceding August.

I might from memory alone, since I have lost my records, add a score of instances, occurring within the last fifty years, in which a twenty-five to twenty-seven day period has within my observation been clearly defined. This is scarcely necessary, however, the most important question being how to clearly identify and eliminate the cause of action.

While studying the phenomena of such weather movements at Ann Arbor, 1855-'56 et seq., two possible causes appeared to my mind, viz.:

The development and movement of storm centers over the globe under the law of equal areas in equal times, or, second, the supposition of the periodic exhibition of polarized solar energy on the earth and its atmosphere. The latter hypothesis appeared to me the most reasonable, since my definition of a full period, as observed, agreed very nearly with the accepted period of the sun's rotation.

Being, however, entirely without data as to the periodicity or mode of action of the solar fluctuation, I was compelled to abandon the investigation.

Within more recent years such recurring periodicity has not escaped the notice of other observers, and if I mistake not, a similar period in thunder storms has been identified by Prof. Hazen, of the Weather Bureau.

I am also glad to notice that recent investigations carried on by the able chief of the Weather Bureau appear to promise valuable results as proving a related periodicity between certain atmospheric changes and the fluctuations of solar energy.

Such investigations are by their nature extremely difficult and tedious, but may, I think, prove later on of value in forecasting.

In what is here offered the writer would be understood as expressing opinions or conclusions from an observer's point of view only.

It seems to me reasonable that the factor of solar fluctuations should affect our atmospheric phenomena as an outside and overlying force, so to speak, intensifying dynamic conditions or changes.

Perhaps we, as yet, by no means fully understand either the extent or mode of action of electro magnetic forces as affecting molecular changes in the mechanism

* San Antonio, Texas.

and dynamics of the atmosphere. If, as seems probable, continuous electric currents may at times exert themselves over a long range of air movement, then it would seem that a possible explanation is suggested of typical and synchronous phenomena not easily accounted for by the theory of translation of air volumes.

Yet all the while this intervention of periodic perturbations of solar energy at the outset appears as an inferior factor only in the chain of phenomena that continually result from the unstable equilibrium of tropical and polar action. But under this intensifying may we not regard both the material and dynamic causes as cumulative and so, therefore, resulting in extremes of weather or climate?

I also conclude that the effect of a casual or periodic exhibition of solar energy would at any given point on the earth affected vary in each instance as to the character of its induced action, referred to a definite period, since the continued permutation of areas of dynamic action through the progressive movement of air volumes alone would cause this, the latter constantly tending to new relations and conditions relative to each other. I cannot, here, undertake to define in detail all the observed characteristics of the weather periods referred to, or of their weekly subdivisions. Briefly they may be said to include distinct systems of both surface and upper currents. They also, sometimes, exhibit a special succession of electrical storms.

The extreme reactionary features that usually define the closing week of a monthly period often include in higher latitudes marked auroral displays, and everywhere increased action of polar currents, either at the surface, as generally during the colder months, or as observed among the cloud strata at other times.

At the beginning of a succession of monthly terms, their character is first indicated by the cloud signals among the highest strata involved; and thereafter throughout the succession of weekly terms there is apparent a working downward to the close, which in winter is often a blizzard at the surface, indicated, however, usually a week ahead by trailing brush-like appearances among the cloud strata.

I think the periods in question, as a rule, less clearly defined in this gulf region than they are in the track of storms moving nearly eastward, from the Rocky Mountains to the Atlantic, that is north of 35°.

But for at least four months past the well known cloud signals have attracted my observation here. Early in October and immediately succeeding the remarkable rainfall and cloud bursts during September, 1894, in western Texas, an indescribable, pale or cold blue sky, suggesting the presence of a cold upper current, was noticed above the higher strata.

Such signals became more pronounced, and November exhibited, in frequent succession, strong dry northers, but the day temperature was rather in excess, while the drop from night radiation appeared greater than usual. A decisive change with norther at 5 P. M. was noted December 2, when very compact masses of cumulo-stratus moved in small scattering groups from S. S. E., with thunder and light rain.

On the 4th clearing weather set in, the "norther" quietly retiring after a pretty even contest with the gulf current.

From this it will be seen that the decisive wintry change, which swept over the Northern States December 1, lost most of its force before reaching the gulf region; but the way was partially cleared for the next monthly onset.

There is a peculiar appearance oftenest observable in connection with cumuli or the intermediate cirro-stratus; it also accompanies at times the forms, and in some degree is always observable as a characteristic of nimbi. It is oftenest seen preceding or accompanying the "norther" of the gulf region, and in that relation shows very distinct the trailing, brush-like appendages and cloud surfaces marked evidently by the abrasion of a cold and dry current suddenly intruding among and underneath warm cloud-bearing strata.

Such signals of boreal reaction are often conspicuous in the warmer months, when the cold air fails to descend to the earth.

They attend our midsummer thunder storms and are occasionally observable even in equatorial skies.

During December the out flowover the gulf from the tropics usually tends to retire with the sun's declination; that is, in place of a direct current northward to Kansas and Dakota, the entire drift turns eastward from the western gulf in parabolic curves, seeking a path of least resistance along the Gulf Stream after reaching the Atlantic across the Southeastern States.

This action appeared to be in progress when the cold wave of December 27, 1894 started for the gulf, and it so happened that considerable cyclonic action was going on east of the lower Mississippi, southeastward toward the northeast Florida coast. It is not surprising, therefore, that the eastern portion of Florida received in full force the "norther" drained by the great river valley. Four weeks later gulf currents, apparently central over the Rio Grande Valley, had increased in force and magnitude over western Texas. Still the theater of most decided cyclonic action lay east of Texas, and apparently over the eastern gulf. This being the condition, cold and high pressure waves of unparalleled intensity, magnitude and persistence sought outlet through the gulf.

Usually in all the western gulf region a cold wave of three days' duration either clears away all gulf storminess or retires, leaving the field open to the genial air of the neighboring tropic.

In this case, however, a life and death struggle ensued. On the outset the advantage appeared to be with the Texas gulf region. Certainly it appeared that the western portion might "hold the fort," while the blasts of Boreas found an outlet across the eastern gulf coast obliquely to the Atlantic. For a while this action obtained; but the increasing force and persistency of the northeast winds, with falling temperature and heavier storm clouds overcasting and moving from the Rio Grande Valley, soon indicated that the final struggle would take place over the old battlefield of the winds—the western gulf region. So it proved when, on February 13 and 14, the heavy storm clouds from the gulf that, holding their place, had so long contended for the right of way along this great aerial avenue between the tropic and the arctic zone, dropped to the earth in the most general and memorable snowfall known to Texas.

At the present date winds from the west quadrants and a cloudless sky prove that a cold wave of the greatest force and magnitude, perhaps, ever recorded over our continent has really driven out of sight all sensible trace of the tropical currents that at this time should, in all this region, bring the buds and flowers of spring.

Whence is derived the immense aerial volumes, and what primarily impels their movement in a succession of such astonishing waves as have just crossed our continent?

This and many more questions relating to the rise and progress of extremes such as above sketched wait the indispensable data possible only from a much more extensive system of observation than now exists anywhere on the planet. Movements of such force and magnitude must by their interaction and by their departure from the normal affect in various modes and over many areas the entire atmosphere of the globe.

Somewhere in antipodean regions, perhaps, opposite conditions of pressure and consequent air movements might be found synchronous, or nearly so, with the extremes of our own continent.

Really, from this point of view, the future of weather science as a whole presents some of the most difficult and perplexing practical problems that confront modern science.

The only hope for their solution rests on the possibility of obtaining sufficient data from reliable stations near enough to each other over the entire globe to enable the student to trace every important line of action and interaction continuously.

No one nation or people can accomplish this by itself. The work demands international organization, one uniform system and one competent head.

While great advances have been made during the last fifty years throughout the civilized world in both practical and theoretical weather science, the results obtained are, for the most part, disconnected, and therefore lacking an element of highest importance.

After collecting tons of observations from instruments of unknown standard, and recorded in terms by no means definite, or strictly scientific, we are only just beginning to work with standard instruments and better educated observers.

In these respects our own Weather Bureau has made important advances, and the same may be said of England and Europe in general.

As a field of observation made eligible by its geographical features, our own continent, in connection with its southern extension and neighbor, offers unsurpassed advantages. If, as seems likely in the near future, an international and Pan-American railway system should be consummated binding and extending over the two continents, then, beginning with the explorations and surveys necessary for such an undertaking a sufficient number of observing stations might be located to command valuable data relating to the incubation and progress of extremes such as I have instanced.

As a further consideration it appears to the writer that henceforth the line of advance of the natural sciences at least must be toward a better knowledge of matter in its minutest divisions and their occult changes and relations.

The all-embracing concept of the correlation of energy at once opened new paths and suggested new methods. In the darker days of the past the audacious quest of science brought frequently the charge of impiety. Especially was this the case when any one passing the apparent boundaries of sensory experience invaded the domain assigned to the fiat of the gods.

Absurd and irrational as such error has ever been, it has still, until a comparatively recent period, operated largely, if in an indirect way, to restrict scientific aspirations and methods. But the method of science must ever be its spirit and life. And more and more as the most important and final method of gaining knowledge of the order and relations of all phenomena we are compelled to seek a deeper insight into that mysterious bond of manifold energy that holds in an infinite grasp of ceaseless and infinite activity all the relations of matter; and may we not also say of mind and intelligence? The ideas here outlined each one can expand for himself, but do they not really and logically point to the study of energy and its various modes of motion, as related to the primary forms of matter, as the only true or direct path to further advance in many departments of investigation?

And all this is not wholly unrelated to the better progress of weather science.

February 15, 1895. LUM WOODRUFF.

THE BAHAMA HEMP INDUSTRY.

THE official report of the governor of the Bahamas, Sir Ambrose Shea, for 1893, states that the most advanced plantation of sisal hemp in which an American syndicate is interested was almost entirely neglected owing to the financial troubles in the United States, and the low price of the fiber, consequent in a great degree on the money stringency, which lessened the desire to prepare the product for market. The business was also much delayed by disappointment in the matter of the scutching machines, which in many cases proved useless. It is highly satisfactory to know that this difficulty is now over, for a machine manufactured by the Todd Company, of New York, has been at length found to work admirably, the fiber being cleaned perfectly, at the smallest possible amount of waste. There can be but little doubt that this machine will be universally adopted, as, besides its efficiency, it is cheaply operated, a woman to feed the machine with leaves, another to remove the finished fiber, being all the labor attendant on this process. It has been for some time a subject of much thought as to how the small cultivators were to utilize their labor where, as in the great majority of cases, they were too poor and their plantings too limited to admit of the cost of a machine. A satisfactory solution, however, has now been found which will be a great boon to this class and will bring the blessings of the industry home to the humblest peasant in the colony. The process is as simple as it is available to all, and consists of a slit being made in the thick end of the leaf, when it is torn asunder, leaving the inner part exposed, and by then soaking it in salt water, which is never far to reach; in about a week the pulp may be removed by hand and the fiber preserved. No waste whatever is found in this method; and it is understood that a man or woman, or grown boys or girls, may turn out from fifty to sixty pounds of fiber as the result of a day's work. The plan is being adopted throughout the colony, and what was for some time deemed a missing link is thus effectively supplied.

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